SEPTEMBER 1951

Journal

VOL. 43 • NO. 9

AMERICAN WATER WORKS ASSOCIATION

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Mathews Modernized Hydrants offer these advantages:

Compression-type valve prevents flooding • Head turns 360° • Replaceable head • Nozzle sections easily changed • Nozzle levels easily raised or lowered without excavating • Protection case of "Sand-Spun" cast iron for strength, toughness, elasticity • Operating thread only part to be lubricated • All working parts contained in barrel—removable without excavating • A modern barrel makes an old Mathews good as new • Available with mechanical joint pipe connections

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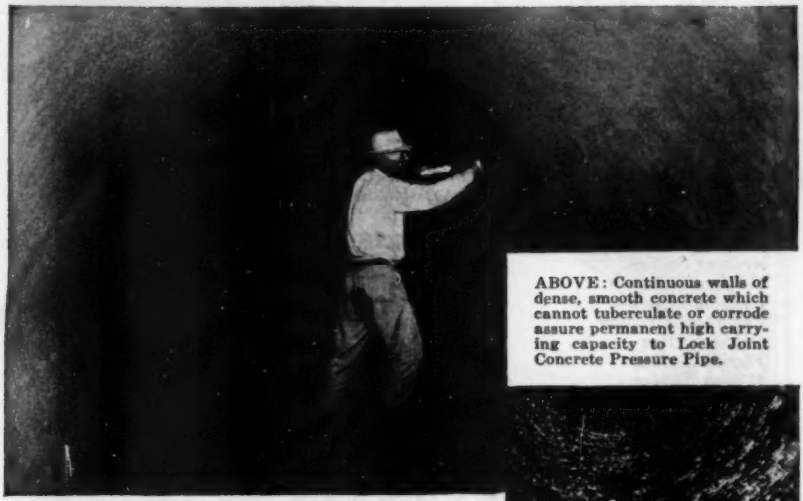
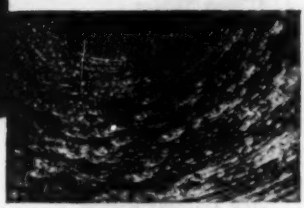


ABOVE: Continuous walls of dense, smooth concrete which cannot tuberculate or corrode assure permanent high carrying capacity to Lock Joint Concrete Pressure Pipe.



ABOVE: The tuberculated condition of this metallic pipe reduces its carrying capacity 50%.

Tuberculated mains—corroded mains—leaky mains—all cost municipalities, taxpayers and industry immense sums every year in added pumping costs, maintenance and repairs. Yet, by the use of Lock Joint Concrete Pressure Pipe, all of this unnecessary expense could be eliminated.

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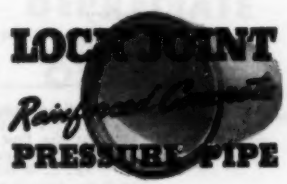

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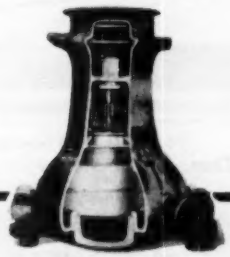

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COMING MEETINGS

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12–14—Minnesota Section at Hotel Nicollet, Minneapolis. Secretary: Leonard N. Thompson, Gen. Mgr., Water Dept., St. Paul 2, Minn.

13–14—New York Section at Whiteface Inn, Whiteface. Secretary: R. K. Blanchard, Vice Pres., Neptune Meter Co., 50 W. 50th St., New York, N.Y.

17–19—Kentucky-Tennessee Section at Louisville Kentucky Hotel, Louisville. Secretary: R. P. Farrell, Director, Div. of San. Eng., State Dept. of Public Health, 420—6th Ave., N., Nashville, Tenn.

19–21—Michigan Section at Whitcomb Hotel, St. Joseph. Secretary: T. L. Vander Velde, Chief, Section of Water Supply, State Dept. of Health, Lansing 4, Mich.

19–21—Pennsylvania Section at Bellevue-Stratford Hotel, Philadelphia. Secretary: L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg, Pa.

24–25—Rocky Mountain Section at Hotel Cosmopolitan, Denver, Colo. Secretary: George J. Turre, San. Engr., Board of Water Comrs., Box 600, Denver, Colo.

24–26—Alabama-Mississippi Section at Buena Vista Hotel, Biloxi, Miss. Secretary: Charles W. White, Asst. San. Engr., State Dept. of Public Health, 537 Dexter Ave., Montgomery 4, Ala.

25–27—Wisconsin Section at Pfister Hotel, Milwaukee. Secretary: Leon A. Smith, Supt., Water & Sewerage, City Hall, Madison 3, Wis.

27–28—Ohio Section at Commodore Perry Hotel, Toledo. Secretary: F. P. Fischer, Sales Engr., Wallace & Tiernan Co., 812 Perry Payne Bldg., Cleveland 13, Ohio

Sept. 30–October 2—Missouri Section at Hotel Robidoux, St. Joseph. Secretary: Warren A. Kramer, Div. of Health, State Office Bldg., Jefferson City, Mo.

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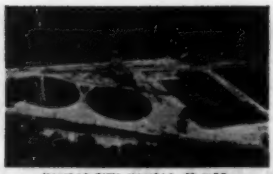

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fluctuating supply
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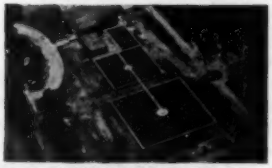

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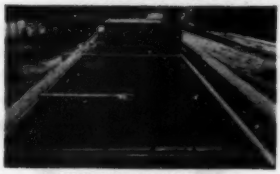

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CEDAR RAPIDS PLANT

Leo Louis, well known superintendent of the City of Cedar Rapids, Iowa, Water Department, with years of experience in the Sanitary Engineering Field of Public Health, says:

"Every water works man knows that water works production is a 24-hour a day job, 365 days a year. Likewise, the managers of water supplies troubled by periodic onsets of taste and odor producing raw water know that we must do our best to constantly maintain a taste and odor free water at the customers' tap. This means that we must use every available chemical method known to the water works profession to treat these waters. The water consuming public may forget to commend us on producing a palatable water, but they will not forget to criticize us for permitting a taste and odor condition to persist in the system."

Aqua Nuchar Activated Carbon has been used to remove tastes and odors from public water supplies for over 20 years by simply adsorbing taste and odor producing compounds. The manufacturers of Aqua Nuchar offer the services of Threshold Odor Specialists to assist water purification plants solve their taste and odor problems. Write, wire or 'phone our nearest office today!

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Journal

AMERICAN WATER WORKS ASSOCIATION

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Water Rates

Committee Progress Report

A committee progress report presented on April 30, 1950, at the Annual Conference, Miami, by Louis E. Ayres, Ann Arbor, Mich.; Chairman, Committee A4.B—Water Rates.

DURING the two years that the Committee on Water Rates has functioned, two panel discussions have been held, one at Chicago (1) and a second at Philadelphia; considerable correspondence has been exchanged; and there have been some changes in committee personnel. On March 16–18, 1951, a task force of the committee met in Detroit to review the preliminary draft of a report prepared by the chairman. The failure of the task force to agree on many of the issues involved, however, has made it impossible to present a committee report at this time. In lieu of a full report, the chairman will endeavor to outline some of the controversial issues and present his personal comments on them.

As water rates and related matters have been discussed by the Association for 69 years, since the second conference in 1882 (2), and as this discussion has grown increasingly vigorous since the acceptance of the Hazen committee report (3) by the Detroit Convention in 1923 and the appearance of the Manual (4) in 1925, it is apparent that there are numerous controversies that are not likely to be resolved either quickly or to everyone's satisfaction.

There is assumed to be no simple answer to any of the controversies. The best answer for any particular community must be adjusted to local views, preferences and conditions. If, however, the elements of the problems involved and the alternative methods which may be followed in formulating rates can be set forth clearly, the areas of controversy can be limited and existing confusion reduced.

The controversies are considered in three groups:

1. The determination of the amount of revenue
2. The allocation of revenue among rate payers and taxpayers
3. The rate schedule or schedules for both normal and special users.

Amount of Revenue

Every water works should receive a gross revenue that provides adequate service and assures the maintenance, development and perpetuation of the system.

Two bases for the determination of revenue have been used widely, and each has its particular field of application. They may be called the "utility" basis and the "cash" basis, for want of better terms.

Utility Basis

The utility basis is required for all privately owned water works and the relatively few publicly owned systems that are under the control of commissions or other regulatory authorities.

This basis requires: [1] the determination of a rate base, or the amount of capital on which the utility is entitled to earn a return, [2] fixing of a fair rate of return on the rate base and [3] approval of depreciation allowances.

Gross revenue on this basis would therefore include: [1] operation and maintenance expenses, [2] taxes, [3] depreciation and [4] a rate of return on the rate base.

Taxes collected through revenue by the privately owned utility include all taxes paid to federal, state and local governments. Publicly owned utilities often pay only local taxes, although the amounts vary from no payment at all to payment of all taxes paid by privately owned systems.

Depreciation allowances are based on the proportions of plant investment that are necessary to return the corresponding capital at the end of the useful life of the physical property. Under commission control, depreciation rates are fixed or approved by order and adjusted when necessary. Public property depreciation rates are frequently higher than necessary for replacements and extensions, and the surpluses are used for other purposes, such as debt retirement.

The rate base and rate of return are determined by court or commission decision in all utilities subject to such control. For all publicly owned, but locally controlled, water works, no such machinery is available, and the determination is made by local authorities with or without the aid of consultants, accountants or other experts.

Courts and commissions determine rate bases quite differently in the various states. The methods range from original cost less depreciation, which is recent practice with many commissions, to reproduction cost (new) less depreciation, which is required by statute in at least one state. A commission must fix a rate base and rate of return for a privately owned utility that will assure sufficient income to enable the utility to borrow money at attractive interest rates—in short, to survive.

There are no such limitations in financing a publicly owned water works. Money is borrowed on general obligation, special assessment or revenue bonds. General obligation or special assessment bonds have a lien on all or a portion of the property of the city and are not affected by the value of the assets or the earnings of the water works. Revenue bonds are secured by a lien on the earnings of the particular water works, but the buyer is not especially concerned with the value of the entire property or rate base. Rather, he wants to know the revenue to be obtained from its operation.

The rate of return for publicly owned water works, is assumed to be

equal to or much less than that for a privately owned utility. The Wisconsin Public Service Commission is required by statute to adopt the basic principle that "a municipally operated water utility is entitled to the same rate of return as that permitted for privately owned utilities."

From the record available (5), it appears that the rate of return on book value varies in municipally controlled water works from none to more than 20 per cent. This range is caused by at least four factors:

1. Indefiniteness of book value
2. Amount of outstanding debt
3. Holding current appropriations for future major improvements
4. Diversion of water works funds to meet deficiencies in other municipal departments.

It is obvious that revenue requirements of most municipally controlled water works are premised not on any rate base or rate of return, but on the cash requirements of the system, all local factors considered. Accepting this fact and outlining a basis for its application should reduce existing confusion.

Cash Basis

The cash basis is a budget basis similar to the budgets of other city departments. The total revenue is based on estimates of cash requirements supported by operating experience and knowledge of future needs.

The items to be included may be separated into basic and optional classifications. The basic items are: [1] operation and maintenance, [2] debt requirements (interest and principal), [3] replacements and [4] normal extensions and improvements.

The optional items are: [1] taxes, [2] appropriations for major improvements and [3] contributions to other city departments.

The basic items cover the essential requirements on which no water works manager, council or commission will disagree, but the optional or additional items involve matters on which there is much difference of opinion and which, in the last analysis, will be decided by local authorities.

Taxes are controversial, but majority opinion would probably favor inclusion of all local taxes.

If it is local policy to avoid debt, partially or entirely, in meeting the cost of major improvements, a reserve should be created and the funds so accumulated should be kept apart, carefully invested and earmarked, without possibility of diversion for other purposes.

Contributions to other city departments is the most controversial item among the optional additions to revenue. Although the practice is common, particularly in the larger cities and those in which normal property taxes yield inadequate revenue, it may be deprecated by those concerned with the best interests of the water works.

Allocation of Revenue

Serious consideration has recently been given to the propriety of collecting a large part of total revenue from property for service rendered by a water works that is apart from and in addition to the commodity supplied. It has long been common practice in many water works to assess some part of the cost to property. Whenever general obligation or special assessment bonds are retired by taxpayers, this practice constitutes a payment by property of a part of the cost of the water works. Financing of distribution main extensions by assessment and

charging property owners for services and meters are forms of charges to property.

A water works certainly benefits public health and property values, but fixing the amount of this benefit must be done arbitrarily. There is at least one water rate schedule that collects a considerable part of its revenue through front-foot assessments, although the general applicability of this basis is dubious. It has been pointed out that in privately owned water companies, there is presently no legal authority to make any charge against nonusers.

Fire Protection

The extent of the charge to property by a water works is practically limited to the fire protection charge, which is largely a charge for benefit to property rather than for the commodity used. Although most water works engineers and managers accept the propriety of a fire protection charge, and courts and commissions usually include allowances for this service in rate structures, this charge is entirely lacking in probably more than half of the municipally controlled water works. In those that make the charge, the amounts range from token payments to excessive allowances.

Three factors which probably contribute to this situation are: [1] absence of general public acceptance of the desirability of such a charge, particularly for properties that are debt-free and pay no taxes, [2] confusion in computing a proper charge and [3] the fact that a fire charge would be included in a tax budget that is already inadequate for other municipal needs —probably the most important factor.

The controversial aspects of the fire protection charge involve the following: [1] amount of the fire demand, [2] amount of the general service demand to be used in determining the ratio of fire to total demand, [3] parts of the plant to which this proportion should be applied and [4] the amount of operation and maintenance expense that should be charged to fire.

The flow requirements for fire demand were established by the National Board of Fire Underwriters many years ago, and draw upon the work of John R. Freeman in 1892 (6). The requirements are based on population and bear most heavily on the smaller towns, being but a small part of the total in the larger cities. The N.B.F.U. appears to have found, according to a recent bulletin (7), that frequently "there had to be material modifications" in the original population bases, depending on the character of the area. To apply the rules now, however, the assistance of experts is needed. This subject might well receive the attention of a committee representing both the underwriters and the water works industry.

Opinions differ on the proportion of the general service demand to be used in determining the ratio of fire to total demand, with suggested ratios ranging from 1½ times the average annual general service demand to a flow equal to that for the maximum day, the maximum 10 hours and the maximum hour. The committee has previously proposed the use of the general service demand for the duration in hours of the fire as specified by the N.B.F.U.

The portions of the system to be considered in computing the fire charge have occasioned much difference of opinion that must be reconciled. Some systems include such important items of plant as supply source and treatment plant; others exclude them.

The chairman considers the fire protection charge to be essentially a capital charge. Aside from the costs of hydrants and their connections, there is but little operating cost beyond the cost of the water actually used. In consideration of all factors, the fire protection charge remains a difficult problem.

Rate Schedules

The primary objective of a rate schedule or schedules is to distribute expense among customers in the most equitable possible proportion to the cost of supplying them with the commodity. Another objective should be simplicity in both classifying users and billing for service.

Users may be divided into normal and special classes, according to the relation of their maximum demand to the average rate of use. Most water users are in the normal classification, but there are special users whose maximum demand, in relation to average use, is higher than normal because of seasonal or intermittent demand. Chief among the special uses is fire protection for the community. Other special uses are sprinkling, air conditioning and refrigeration, supplies to golf courses, irrigation and use by bottle washing and similar plants. This category often includes large industries and suburban areas.

With few exceptions, single rate schedules have heretofore been applied to all types of users, but it appears that a differentiation is desirable. To classify users, their demands must be separated on the load curve. A great deal of information is needed to allocate the demands on the maximum day to normal users, to all special users and to fire fighting. The sum of these demands plus a possible allowance for community growth should represent the total plant capacity.

On the basis of the allocation of plant capacity to each type of use, fixed charges may be set together with any specific operating costs chargeable to each use.

Distributing Remaining Costs

The balance of this discussion deals with two bases for the distribution of the remaining costs after deducting the charges to fire protection and special uses or the formulation of rate schedules for normal users. These two are designated as the "demand" basis and the "customer-cost" basis.

The chief difference between these is the amount of the service charge. The demand basis generally distributes a considerable part of all capital costs, customer costs and varying portions of operation and maintenance expenses to customers through a service charge. The customer cost basis, however, limits the service charge to customer costs.

The Demand Basis

An early example of the demand basis was the 1905 Coffin committee report of the New England Water Works Assn. (8), in which the plan was to assess all costs "which are affected but little by the amount of water used on the frontage of the lot on the street." This report assumed that approximately half the gross revenue would be raised by ordinary frontage assessments and the balance through water sales.

For obvious reasons, the report was never generally accepted, but the theory had been applied by electrical industry which substituted consumer demand for front-foot assessment.

Although in theory the demand basis is attractive, it is difficult to achieve

equity among customers when applying it. It has never been agreed what should be included as demand charges. It is usual to include all fixed charges and often portions of operation and maintenance expenses. It has also been difficult to find an equitable method of distributing the service charge among users. It is usually allocated in proportion to the relative capacities of individual meters, but this practice collects most of the total service charge revenue from the domestic meter.

The committee is considering rules for applying the demand basis that should improve the equity of its application. The following assumptions are tentatively proposed:

1. The total of the so-called demand costs included in the service charge should be no more than 50 per cent of the capital costs of depreciation, taxes and return on investment. The balance of the capital costs will be charged to the commodity. Such an assumption is obviously arbitrary, but its justification may be rationalized. Capital costs are as much a part of the cost of production as labor, fuel, electricity and other such expenses. No business produces goods without capital costs. Some part of depreciation, taxes and interest should therefore be included in the commodity portion of the cost. Excluding special uses, it is not uncommon to experience a maximum day of twice the average daily use. Under these conditions, the size of the base plant is one-half the total plant, and one-half of the capital costs may therefore be considered chargeable to the commodity, the other half to demand.

Further justification for this arbitrary equal division of capital costs is found in a recent court decision, *Colorado Interstate Gas Co.* v. *Federal Power Commission. U.S. Supreme Court, 324 M.S. 581,* in which return and income taxes are allocated half to volume and half to demand.

2. Demand costs should be distributed to meters on the basis of the actual maximum demand through meters, in size groups, in lieu of individual meter capacities. The momentary demand of any single dwelling is not a measure of a particular customer's effect on plant capacity. It is the group demand of a residential area combined with the group demands of other types of areas that fixes the size of the required plant.

Many additional field data are needed to compute group ratios, and these data should be checked against local operating records. As a tentative application, the committee made the assumptions that the maximum demand of all residential meters might be six times the average rate of use, the maximum demand of large meters serving an industrial area might be only twice the average use and that intermediate sizes of meters would have intermediate ratios. The application of these assumptions in Detroit is shown in

TABLE 1

Relative Group Maximum Demands in Detroit Compared With Relative Meter Capacity

Meter Size *in.*	Relative Group Max. Demand	Relative Meter Capacity		
		Displacement	Compound	Current
⅝	1	1.0		
¾	2	1.5		
1	4	2.8		
1½	10	4.3		8.0
2	25	8.7		12.5
3	45	13.2	1.5	25.5
4	90	19.5	15.0	36.0
6	170	34.5	30.0	69.0
8	300		76.0	136.0
10	500		85.0	173.0
12	1,000			187.0

Table 1, which gives the relative demand for water of each customer in a group classified by meter size, in comparison with the relative demand based upon the nominal capacities of the individual meters.

Customer Cost Basis

The customer cost basis was presented by the Michigan Section's Committee on Water Rates (9). It is not new in its theory, but constitutes a revision of the basis outlined by the Association's committee of 1923 (3), and is in accord with a previous recommendation of the New England Water Works Assn. (10). It avoids the controversy over demand by leaving all capital costs in the commodity rates. The service charge includes:

1. All accounting costs of reading, billing, collecting and such operations, to be distributed equally among customers.
2. All customer costs, both capital and operating, connected with meters and services, to be distributed in an approximate ratio proportional to meter sizes.

Commodity Rates

In the past, cost distributions have allocated expense to: [1] fire protection, [2] capacity or ready-to-serve costs and customer costs and [3] commodity costs. No two allocations mentioned in the available literature are the same, and no specific rules have been found to apply commodity costs to the steps of the schedule. Step quantity limitations are suggested in *Water Works Practice* (4).

The Michigan Section committee report (11) proposed a functional basis for allocating costs to production, distribution, customer costs, hydrants and connections. This type of distribution affords a basis for the computation of unit rates.

The wholesale, or lowest, unit is obtained by dividing the total production cost by the total plant output. The domestic rate may be obtained by adding to the lowest rate the domestic increment, obtained by dividing the distribution cost by the total annual sales through all $\frac{5}{8}$- and $\frac{3}{4}$-in. meters. The intermediate rate, as the name suggests, is in between.

The domestic rate should apply substantially to all domestic customers. Large users should obtain most of their water at the lowest rate. Unit rates and steps must be adopted that will produce the necessary revenue when applied to the system's customers.

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U.S.P.H.S. Position on Fluoridation of Public Water Supplies

By H. Trendley Dean

A summary of fluoridation data received from H. Trendley Dean, Director, National Inst. of Dental Research, U.S. Public Health Service, Bethesda, Md., Aug. 14, 1951.

TO obtain authoritative answers to a number of inquiries about fluoridation, A.W.W.A. phrased and forwarded to the U.S. Public Health Service the five questions most frequently asked. These, together with the replies received from Dr. Dean, are presented below. Summarizing the latest data available, these answers may give a clearer understanding of fluoridation.—*Ed.*

Safe Concentration

1. *Upon what evidence has the U.S. Public Health Service based its conclusions that the adjustment of the fluoride concentration of a public water supply to approximately 1 ppm. is not harmful to the consumer?*

The conclusions regarding the physiological effects of fluoridated drinking waters are based upon critical analyses of the results of a large number of epidemiological and experimental laboratory investigations.

It must be emphasized and reiterated that whether or not fluorine is toxic depends on its concentration; 1 ppm. is well below the level of toxicity.

The presence of fluorides in drinking water is not unique. For generations, large population groups have been using domestic water supplies that contain approximately 1 ppm. of fluoride with no evidence of any ill effects.*

Fluorine is not now, or probably never will be, absent from our diets. It is present in some trace quantity in all body organs and tissues, being particularly common in the bones and teeth. Exclusive of drinking water, the average diet contains 0.2–0.3 mg. of fluorine daily. There is no hazard of cumulative bone toxicity due to the use of fluoridated drinking water at the recommended level of 1 ppm.

Reports of toxic effects of fluorine should be critically and dispassionately analyzed. Attention should be given to determining whether:

a. The effects were the result of an excessive intake of fluorine, or

b. The results that are reported have been supported by scientifically

* An example, although possibly not typical, of the natural fluoride content of water supplies of an entire state is available from a brochure published in 1950 by the Iowa State Dept. of Health, entitled "Fluoride in Public Water Supplies of Iowa." Of the 959 well water sources tested, all except 57 contained fluoride, and 178 contained fluoride in excess of 1 ppm. The highest natural fluoride content was 4.0 ppm. Of the 49 surface water supplies tested, all but four contained fluorides; two contained 1.2 ppm. and one source 1.0 ppm. All others contained less than 1.0 ppm. Thus a large portion of the population of Iowa is drinking water which contains natural fluoride.

acceptable experimental or clinical evidence.

Reports on the toxic effects of fluorides appear from time to time, but on critical analysis, they have been found to bear no relevance to the proposal of adding a trace (1 ppm.) to a public water supply.

Not a Medication

2. *Is it correct to designate fluoridation of a public water supply as mass medication?*

It is not correct to designate fluoridation of a public water supply as mass medication. Medication implies the application of a medicinal substance or agent for the treatment and cure of a disease. Fluoridation is not recommended for the treatment and cure of dental caries (decay). Dental decay is a nonhealing lesion; dental enamel (the covering of a tooth) once injured never repairs itself—with or without medication. Fluoridation simply prevents the initial development of dental decay. Fluoridation of public water supplies simulates a purely natural phenomenon—a condition set up by nature itself in those communities fortunate enough to have approximately 1 ppm. naturally present in the public water supply.

Fluoride and Cancer

3. *What do comparative epidemiological studies show in the incidence of cancer in cities in which the public water supply is relatively free of fluoride (0.2 ppm. or less), and those in which water supplies contain approximately 1 ppm.?*

During 1937, 1938 and 1939, the National Cancer Inst. made field studies of cancer prevalence in ten metropolitan areas. One was Denver, in which most of the community water supply contains approximately 1 ppm. of fluorides. The most nearly comparable city was San Francisco, in which the community water is substantially fluoride free.

Total cancer rates were 518.2 cases per 100,000 population at Denver and 525.9 at San Francisco. Rates for cancer of the breast were 91.1 at San Francisco and 85.0 at Denver. If skin cancer is omitted, the rates become 446.2 at San Francisco and 396.9 at Denver. In Denver the average elapsed time from diagnosis of breast cancer to death was 18.2 months; in the other nine areas combined, the average time elapsed was 18.0 months. At the end of 18 months, 61 per cent of cases had died at Denver, and 56 per cent at San Francisco. This finding did not take account of whether a lesion was incipient or advanced when first diagnosed. This factor was corrected when the cities were resurveyed ten years later and the new data, now in the process of publication, indicate that there is no difference in the time between onset and death from breast cancer in Denver and San Francisco.

There is nothing in the data from the Denver and San Francisco survey which would suggest that the prevalence or malignancy of cancer is affected by exposure to a fluoride-containing water.

Policy on Increasing Fluoride Content

4. *What is the present policy of the U.S. Public Health Service toward fluoridation of public water supplies in those cities in which the supply naturally contains less than the optimal amount fluoride necessary to control dental decay adequately?*

The policy of the U.S. Public Health Service is to recommend increasing the fluoride concentration to the optimal level of 1.0 ppm.

Pertinent to this question is a statement made April 24, 1951, by Surgeon General Scheele of the Public Health Service in testimony presented to the Senate subcommittee on appropriations: "During the past year, our studies progressed to the point where we could announce an unqualified endorsement of the fluoridation of public water supplies as a mass procedure for reducing tooth decay by two-thirds."

Policy on Reducing Fluoride Content

5. *What is the policy of the U.S. Public Health Service in relation to those towns where the public water supply naturally contains more than 1.5 ppm. of fluoride?*

For several years, the U.S. Public Health Service in cooperation with state health departments has been conducting investigations relative to removing excessive amounts of fluorides from public water supplies for the purpose of preventing the development of mottled enamel. These studies are continuing, and, when economically feasible and satisfactory methods are developed, their use will be recommended. Development of fluoride removal methods are essential for areas like West Texas and the Panhandle area, where no other source of domestic water is available except that containing excessive amounts of fluorides.

The problem of excessive amounts of fluorides in domestic water supplies may be met in other ways where conditions permit:

a. It may be more economical and satisfactory to abandon the high fluoride water supply and substitute one free from excessive amounts.

b. If the fluoride content is not too high (2.0–2.5 ppm.), it may be possible to dilute it with another water supply, low in fluoride, to bring the final concentration within optimal limits.

c. If excessive fluorides are coming from a particular geological stratum, it might be well to consider the possibility of reducing the fluoride content of the water by a "plug back" of the well (casing off water from an undesirable aquifer) or by such other methods as local conditions permit.

For the statement of policy adopted by the A.W.W.A. on fluoridation of public water supplies, see the August 1951 issue of the Journal, p. 602.

Compensation of Water Works Personnel

Preliminary Committee Report

A preliminary committee report presented on May 1, 1951, at the Annual Conference, Miami, by Leon A. Smith, Supt., Water Works and Sewerage, Madison, Wis.; Chairman, Committee A 2–C, Compensation of Water Works Personnel.

THE objective of the Committee on Compensation of Water Works Personnel is to set up a formula to guide water works management in establishing a fair salary schedule. At the outset, the committee recognized that there are at least two approaches to its problem:

1. The proposed formula may be based on the salaries paid for similar types of positions by other employers in the specific communities involved.

2. It may be based on such factors as population served, number of consumer accounts, value of plant, total water revenue and average daily flow or pumpage into the distribution system—using these factors, which indicate the scope of water works operation, to modify a separately determined minimum base pay.

Because endless comparisons would be involved in applying the first method on a nationwide scale, the committee undertook to assemble the available pertinent facts required for the second approach. A questionnaire designed to obtain these facts as well as salary information on eight typical jobs was prepared and sent to a selected group of utilities in ten population classifications. The 280 replies listed in Table 1 were received from utilities that provided an excellent sample of population, geographical distribution and ownership. These replies were then carefully analyzed to determine their validity as a basis for a salary formula.

Limitations

Preliminary work could not, of course, yield definite conclusions. So much caution is necessary in interpreting the data resulting from an investigation of this type that only very general indications of the situation under study can be expected. The questionnaire may have been sent to an unrepresentative group. Replies to any mail questionnaire may be inaccurate or incomplete because of misconstruction of the questions. Mail questionnaires are almost always answered by those whose answers will be received most favorably.

There are many other variables which must be considered. Salaries of water works employees, like other salaries, are in a very fluid state at present because of the rapidly increasing cost of living. Even if they were stable, it would be virtually impossible to assign proper weight to such factors as employee benefits and working conditions. Salary scales of a particular city may vary by as much as 50 per cent for some types of employment from the scales existing in one of its suburbs. Job titles, however carefully described, may fail to fit the job functions of any given community. All these factors should serve to indicate

TABLE 1

Utility and Job Classifications Used in Survey

Symbol	Jobs Reported
1A	Manager or Superintendent
2B	Chief Engineer
3B	Office Manager
4C	Head of Production Group
5C	Head of Purification Group
6C	Head of Distribution Group
7D	Distribution System Shop Foreman
8D	Meter Reader or Bill Collector

	Population	No. of Replies
AA	Over 1,000,000	7
A	500,000–1,000,000	10
B	300,000–500,000	19
C	200,000–300,000	11
D	100,000–200,000	38
E	50,000–100,000	53
F	30,000–50,000	39
G	10,000–30,000	61
H	5,000–10,000	30
I	Under 5,000	12
	TOTAL	280

how extremely inconclusive any results of the survey may be. A few general observations can be made, however, and some of the benefit plan data are worth presenting in their present form.

Vital Statistics

A number of interesting facts not directly related to compensation were uncovered by the survey. The standard work week is 40 hours for all classes of water utility employees in cities of 50,000 and greater populations, and approaches 44 hours in cities of less than 50,000. The number of full time employees appears to be approximately 1 per 1,000 population served, regardless of size. In the 30,000–50,000 population group, the average number of employees is 40, in the 100,000–200,000 group it is 146 and in the 300,000–500,000 group is 440.

The variations are due to a number of factors. Occasionally the supply system is exceptionally large for the population served and requires a proportionally greater number of employees. Some utilities use well water, which requires no treatment except chlorination and perhaps softening. The personnel required in filter plants varies, depending upon the type of treatment. Topography sometimes necessitates an abnormal number of distribution zones.

Another interesting revelation involves the laying of mains. The study indicates that 54.6 per cent of the utilities lay their own mains, 19.0 per cent let the work by contract exclusively, and 26.4 per cent do part of the work by contract and part with their own forces. The small- and medium-sized utilities tend to use their own employees in laying mains, whereas the larger cities use contractors.

There is approximately one customer for every five consumers. In the larger utilities, those in cities of more than 500,000, the average is one customer for every six consumers,* whereas in the smaller communities there is one customer to each four and one-half consumers.

Salaries

For cities within the same size group, the salaries of all key personnel vary so widely that no standards can be set for the groups. Salaries of key personnel bear little, if any, relation to the size of the city or its water works operation. This situation should be remedied. Reasonable stability does exist

* Customers are counted by number of active services; consumers, by number of actual users.

in lower level groups, such as shop foremen and meter readers.

It was thought that a relation might exist between benefits and salaries—that lower wages might be balanced by greater allowances for vacation, sick leave, retirement and other benefits—but correlation tables developed to compare benefits and salaries did not support this expectation. It therefore appears that the benefit plans have been developed without reference to pay levels and are not established to supplement basic salaries.

Average salaries of superintendents or managers range from $1,047 per month in cities of more than 1,000,000, to $280 a month in small communities. Salaries of chief engineers vary from $918 to $248. Salaries of office managers are between $676 and $219. The other technical groups receive salaries from approximately $650 to $235. Shop foremen are paid from $438 to $200, and meter readers or inspectors from $306 to $200.

Practically all cities of more than 50,000 population hire both an office manager and a chief engineer in addition to the superintendent. Almost all cities of more than 10,000 have full time technicians as head of production, purification and distribution, and there is usually more than one such assistant in most communities of more than 30,000.

Benefits

Paid Vacation. Of the utilities reporting vacations for one year's service, about two-thirds specified 2 weeks with pay, and about one-third specified 1-week vacations. Only three utilities allowed a 3-week vacation, and they were the larger ones of those in Table 2. For two year's service, there was little deviation from 14 or 15 days.

TABLE 2

Paid Vacation for Years of Service by Population Groups

Pop. Group	Vacation Time* for:					
	1 Year's Service			5 or More Years' Service		
	1 Week	2 Weeks	3 Weeks	2 Weeks	3 Weeks	4 Weeks
AA	0	6	0	0	4	0
A	1	6	1	1	3	1
B	2	11	1	3	4	0
C	4	7	0	3	7	1
D	8	27	1	5	7	0
E	11	35	0	6	10	0
F	11	23	0	2	7	0
G	18	24	0	4	13	0
H	14	13	0	2	5	0
I	13	6	0	0	3	0
TOTAL	82	158	3	26	89	2
Percentage	33.7	65.0	1.3	22.2	76.1	1.7

* 12–16 days recorded as two weeks; 6–11 days recorded as one week.

For analysis, service beyond five years was lumped into one class because most plans do not vary after 5 years' service; or if they do, the variation is slight. Of those utilities having a plan for more than five years' service, 76 per cent gave a three-week vacation. Many utilities provide for 2 weeks for 1 or 2 years' service, with no further provision for long years of service.

Approximately 40 per cent of the utilities have graduated vacation plans in operation, with vacation time varying directly with various specified periods of service. A representative plan cited "6 months, 3 days; 1 year, 1 week; 3 years, 2 weeks; 5 years or more, 3 weeks." A few plans provide one day per month with an accrual provision.

The data from all types of utilities of all sizes as shown in Table 2 indicate

that the established policy is to give employees not more than a two-week vacation after one year's service. After five years' service, three weeks is the established amount.

Sick Leave. The standard policy for most utilities provides 16 days or more sick leave at full pay after two years' service. Six utilities reported no sick leave policy, whereas 53, or about 19 per cent, had no fixed policy. Those with no fixed policy were mainly the water works for cities of less than 50,000 population.

Of those who have a full-pay policy, eight to fifteen days sick leave is most common for one year of service or less. For more than two years' service, sixteen days' leave or more was generally reported.

Some companies have a uniform sick leave policy applying to all employees regardless of service time. These usually give seven to fifteen days' leave at full pay. The sick leave policies are summarized in Table 3.

Pensions. Pensions are paid by most cities of more than 20,000 population. Plans vary considerably, but the retirement age is ordinarily 65 years. Most often the pension is based upon the last five years' salary. The next most common base is final salary, and third is average earnings during the entire period of employment. Table 4 shows the number of cities using the various periods for basing retirement pay.

Of 272 utilities reporting on pensions, 195 said they had a plan in operation other than federal social security, and 77, or 28.3 per cent, specified no pension beyond the federal plan. These figures pertain to all utilities, large and small. Of those having no plan, 71 per cent are in the population groups G, H, and I (less than 10,000), whereas only about 9 per cent of the large utilities, AA through D,

TABLE 3

Sick Leave Policies

Pop. Group	No Policy	No Fixed Policy	Half Pay	Full Pay Policy—*years of service*												Other
				Less than 1			1			2–5		Over 5		Uniform		
				7 days or less	8–15 days	16 days or more	7 days or less	8–15 days	16 days or more	15 days or less	16 days or more	15 days or less	16 days or more	0–15 per yr.	16 or more per yr.	
AA			2	1	1	1		2	1		2		1	1		1
A			1	1	1	0	1	6	2		3		1	1		
B		2	2		1			8	1		1		2	6		1
C	1	1	1	1	2		1	3			1		2			
D		1	4	2	8	1	1	13	6		7		7	11		3
E	1	6	3	1	5	1	2	16	4	2	5	1	6	10	2	3
F	1	8		2	7		2	19		3	8		6	8		
G	3	11	10		8		4	17	3	2	9	1	8	6	1	
H		13	5	1	7		4	12		1	6		6	5		
I		11	4		3			6		1	4		4	2		
TOTAL	6	53	32	9	43	3	15	102	17	9	46	2	43	50	3	8

TABLE 4

Pension Pay Base

Pop. Group	Years Preceding Retirement								Avg.	Flat Amount
	2	3	4	5	10	15	Highest 5	Final		
A and AA	1	—	—	6	1	—	—	2	—	1
B	—	—	—	1	6	1	—	1	2	1
C	—	—	—	2	1	—	2	1	1	—
D	1	1	—	10	4	—	1	5	8	1
E	—	1	—	13	2	—	1	7	4	1
F	—	2	1	12	3	—	3	4	5	1
G	—	1	1	6	4	—	1	5	4	—
H	—	3	1	2	—	—	—	1	1	—
I	—	1	—	2	1	—	—	1	—	—
TOTAL	2	9	3	54	22	1	8	27	25	5

report no utility operated pension plan (Table 5).

Employer contribution is most common for all sizes of utilities, and about 94 per cent reported plans require an employee contribution.

There is no difference between those offering benefits before normal retirement age for other than medical reasons and those who do not. Fifty-two per cent reported these benefits available, whereas 48 per cent make no such provision for prior claims. This pattern is generally consistent throughout all population groups.

The retiring age varied from 55 to 70 years, but the extremes were mentioned only occasionally. The usual age is 65 years and no appreciable variation between retirement ages for

TABLE 5

Pension Plans

Pop. Group	Pension Plan		Avail. to All After Tenure		Employee Contribution		Benefit Before Retirement		Normal Retirement Age (Male) *years*		Pay Base			Most Common Pension Earned With 30-Year Service
	Yes	No	Yes	No	Yes	No	Yes	No	Mode	Range	Career Avg. Pay	Final Pay	Last Few Years	
AA	7	0	7	0	7	0	5	2	60	70–55	0	0	7	Approx. 50% Avg. Pay Last 5 Yrs.
A	9	1	9	0	8	1	4	4	65	70–60	0	1	8	50% or Less Avg. Pay Last 5 or Less Yrs.
B	15	2	15	0	14	1	13	2	65	70–60	1	1	13	50% or Less Avg. Pay Last 10 Yrs.
C	10	1	10	0	10	0	8	2	65	70–55	1	1	8	50% Avg. Pay Last 10 Yrs.
D	33	3	33	0	31	2	17	16	65	70–55	4	0	29	50% Avg. Pay Last 5 Yrs
E	41	7	41	0	34	7	16	26	65	70–55	5	6	30	50% Avg. Pay Last 5 Yrs
F	33	8	33	0	33	0	20	13	65	70–55	5	4	24	50% Avg. Pay Last 5 Yrs
G	30	17	29	1	29	1	11	19	65	70–60	3	3	24	50% Avg. Pay Last 5 Yrs
H	11	25	11	0	11	0	5	6	65	70–55	1	1	9	50% Avg. Pay Last 3 Yrs
I	6	13	5	*	6	0	3	3	65	65–55	0	1	5	50% Avg. Pay Last 3 Yrs
TOTAL	195	77	193	2	183	12	102	93						
Percentage	71.7	28.3	99.0	1.0	93.8	6.2	52.3	47.7						

* One utility did not answer.

male and female employees could be found.

The most common plan in all population groups is a specified proportion of average pay for the last period of years. The most frequently used figure, after 30 years of service, at normal retirement age, is 50 per cent, with many more figures below the mode than above it. The base period most often used is the last five years, but the plans are so varied that it is hard to state this as a generality, as 10 years and less are also used extensively.

The plans involving proportion of career average pay and proportion of final pay are used less extensively. Some fixed retirement payments were reported and maximum benefits were also often specified.

Other Benefits. Among other benefits mentioned were group life insurance, hospitalization, disability pensions, death benefits other than insurance and other welfare plans. These plans vary greatly and are not as yet commonly found among utilities.

Conclusion

If a compensation formula is to be presented it must be worked out very carefully. The chairman's personal belief is that the formula should be based upon a minimum wage scale of $400 per month for the salary of the chief executive, with additional increments depending not only upon size of the utility operations as indicated by revenues, population, pumpage and other such factors, but upon geographical location. The cost of living in the southern states is clearly lower than in the northern states because clothing, heating and housing are less expensive in the warmer climates. Many of the cities have salary schedules keyed to the cost of living reported in the Consumers' Price Index of the U.S. Department of Labor's Bureau of Labor Statistics. This index is available, however, only for the larger cities. In Madison, Wis., wages are keyed to the cost of living index of the city of Milwaukee and are adjusted twice a year —January 1 and July 1. The dollar value of each index point varies from $1.00 per month in the lowest salary range to $1.90 in the highest.

The above ideas, however, represent only one possibility. It will be impossible to present a final report until all the variables have been resolved. Meanwhile each of the members of the committee, listed below, has been asked to act as a clearing house for suggestions from members of the A.W.W.A. living in his vicinity.

Charles J. Alfke,
Exec. Vice-Pres.
Hackensack Water Co.
Weehawken, N.J.

G. E. Arnold, Director
Water Dept.
Civic Center
San Diego, Calif.

E. Sherman Chase
Metcalf & Eddy
1300 Statler Bldg.
Boston, Mass.

Charles C. Casad, Supt.
Water Dept., City Hall
Bremerton, Wash.

D. D. Gross, Chief Engr.
Board of Water Comrs.
Denver, Colo.

Albert R. Davis, Supt.
Water Dept.
Austin, Tex.

Leo Louis, Supt.
Water Works
Cedar Rapids, Iowa

Hal F. Smith,
Sr. Admin. Asst.
Dept. of Water Supply
Detroit, Mich.

Paul Weir, Gen. Mgr.
Dept. of Water Works
City Hall
Atlanta, Ga.

J. S. Longwell, Gen. Mgr.
East Bay Munic. Utility Dist.
Oakland, Calif.

Water Supply Notes on the Kansas Flood

THE impact of the recent Kansas flood has been tremendous. Losses reckoned at a billion dollars, homeless at a hundred thousand and economically dislocated at half a million have aroused not only the sympathy of the nation but its desire to do something about the matter of flood control and —perhaps unfortunately—to do it *now*. What will come of current discussions of such plans as those for Pick-Sloan dams, for a Missouri Valley Authority or for a less immediately appealing project of flood prevention by land management is difficult to predict, but it can be hoped that the aroused public will be neither too impatient nor too quickly disinterested to insist upon a sound program. At any rate, a more reasoned review of the flood story and its overall effects will be possible next spring when the Association's annual conference is held on the scene, at Kansas City.

Meanwhile, an outline of the strictly water supply effects of the flood itself, developed through certain A.W.W.A. members in the area and through the office of the Kansas State Board of Health, which did yeoman service during the emergency, will give some idea of the types of difficulty encountered. City by city, along each river basin involved (Fig. 1), the Kansas water works in the line of flood, with notes on their experience, are:

Kansas (Kaw) River

Kansas City. At Kansas City, Mo., failure of the Turkey Creek Pumping Station, which was flooded to a depth of 7½ ft. (Fig. 2), threw the entire supply load on the East Bottoms Pumping Station. This additional load and the fact that some water was pumped into the flooded ground level reservoir at the Turkey Creek site until the valves were shut resulted in low pressure throughout the city and no water at some of the higher elevations. This condition was rectified five days after the flooding when the Turkey Creek Station was restored to service, and five days later service was again normal. As soon as word of the flood was broadcast, the mayor of Winnipeg, Man., offered and the mayor of Kansas City accepted the services of floodwise A.W.W.A. members W. D. Hurst and N. S. Bubbis as well as H. L. Briggs, Asst. Gen. Mgr. of the Winnipeg Hydro-electric System, in an international mutual aid gesture.

At Kansas City, Kan., the city water and light plant was saved by a last-minute ring levee erected by an all-night crew of 500 national guardsmen, city employees and volunteers who managed to build approximately a foot ahead of the rising water. The plant maintained uninterrupted service; but with flooded areas south of the Kaw, some water was pumped into the flooded zone. The Argentine Reservoir south of the Kaw had to be emptied, shutting off its supply to the Kansas City Suburban Water Co.

Suburban Kansas City, in northeast Johnson County, Kan., is served by the Kansas City Suburban Water Co. and the J. C. Nichols Co. cooperative water system. Neither of these companies has an independent source of

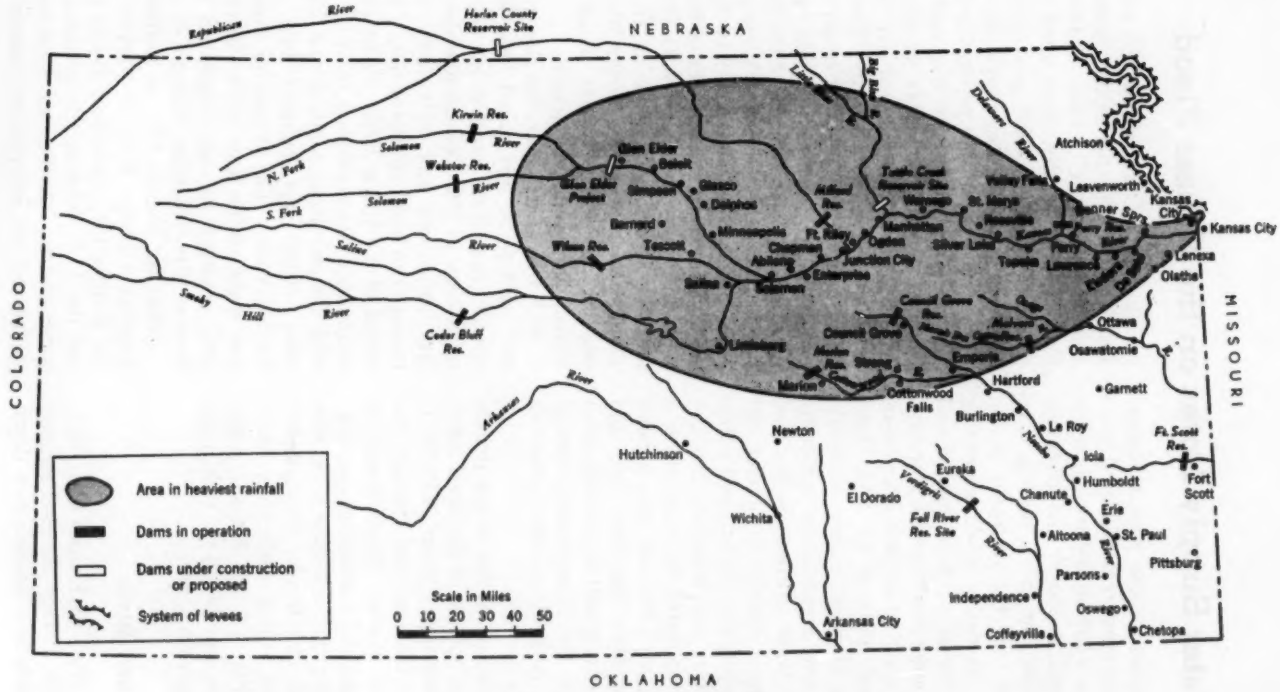

Fig. 1. Kansas Flood Area

The rivers which flooded in July are shown with the towns and reservoirs that are discussed.

supply. The former obtains half its supply from each Kansas City, the latter, all from Kansas City, Mo. As a result, the eight small incorporated areas served by these companies were without water except in the very lowest portions, to which the systems drained. The Nichols Co. supply was restored by the end of July, but the Kansas City, Kan., supply to the Kansas City Suburban Water Co. had not then been reestablished because excessive leakage and use in the city had prevented filling of the Argentine Reservoir. During the worst of the flood, the Suburban Co. trucked water from Kansas City, Mo., into its service area and obtained an additional supply from a U.S. Public Health Service plant set up on Indian Creek, south of the developed area of Mission Township in Johnson County, and from two purification units operated by the 110th Engineers, a Missouri National Guard unit.

Bonner Springs. The water plant was flooded and its power failed. The city was without water for approximately two days until a temporary 4-in. main was laid to the private well supply of the Lone Star Cement Co.

De Soto. The power failed, but water from an elevated tank was rationed for two days, and no particular trouble was experienced.

Eudora. The clear well was flooded, and the plant was without power for almost two days.

Sunflower. The wells that serve both the town and its large ordnance works were partly flooded and the power lines to both intake and wells failed.

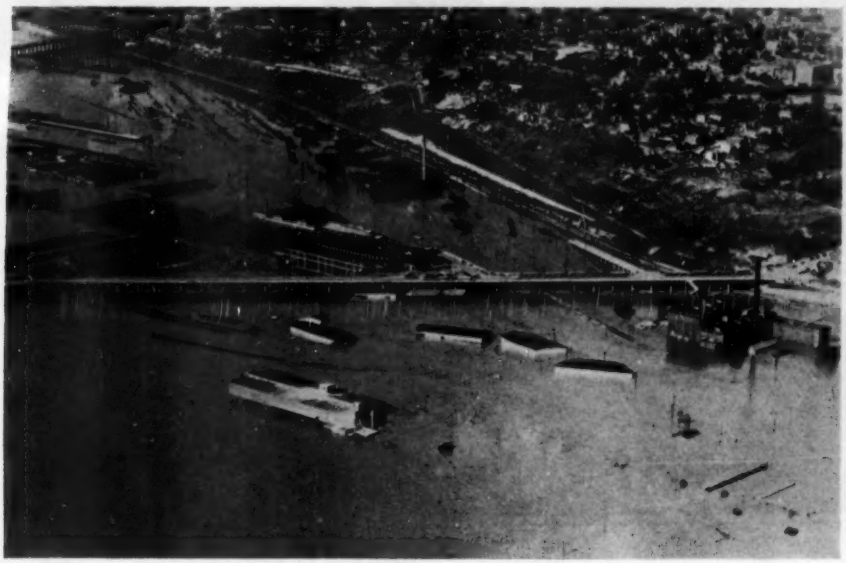

Fig. 2. Turkey Creek Pumping Station

Station shown at right center, flooded. Until valves could be shut off, a large amount of water was pumped into the ground level reservoir at the site.

Lawrence. The river bottom wells and the intake were flooded, but the department pumped "ditch" water to the mixing basin and was able to continue service without interruption.

Topeka. By herculean efforts, the water plant was saved and kept in service throughout. As the dike at the plant was not as high as the seawall, emergency raising was necessary (Fig. 3). The access road to the plant was flooded and an emergency one built.

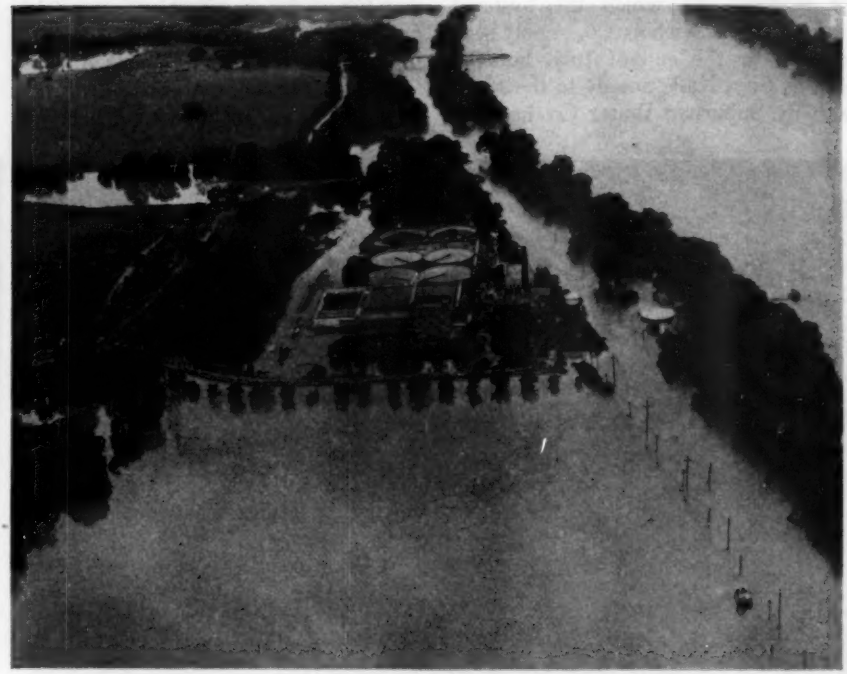

Fig. 3. Topeka Water Plant

Bridge in background shown collapsed into Kansas River, which has inundated city water intake at center right. Low-service pump station and oil storage tank across tree line from intake is adjacent to the now submerged Rock Island Railroad tracks. The dike in the lower foreground, behind which an emergency road to the plant was constructed, was approximately 2 ft. lower than the seawall, but was built up with sandbags. The two empty tanks separated from the others by the new transfer flume are the new raw water settling basins, and the empty square tank is the secondary settling basin, in front of which is the new clear well—now just a water-filled hole. The buildings at the extreme right of the plant are the pump station, steam and electric power units. The water at the left of the settling basins is only a few inches deep.

Perry. Power failed, but a full elevated tank provided a supply for greatly diminished use. For several days, even this was not required as the town was completely evacuated previously.

Settlement occurred at the high-service pumping station but was not too dangerous except for the old steam turbine unit.

Silver Lake. The power to the well field failed.

Rossville. The power to the well field failed.

Wamego and St. Marys. No water supply trouble was experienced.

Manhattan. The well field was flooded, so flood water was pumped through the softening plant. The town was badly damaged, but the water works survived in good condition, and the well pumps were saved. One well connection was lost during the floods in June.

Ogden. There was trouble with the power to the well field.

Fort Riley, Junction City, Chapman, Enterprise and Abilene. No trouble was experienced with water supply.

Solomon River

Solomon. The city was inundated. Water mains were reported breaking after the flood had receded.

Minneapolis, Delphos and Glasco. No trouble was experienced with water supplies.

Simpson. The wells were flooded and out of service for four or five days. Water was hauled into town during the period.

Beloit. The new city water plant is high and dry, and emergency methods made it possible to put the new city power plant into service a short time before the old one was flooded.

Glen Elder. One well was flooded and the others could not be used because of power trouble.

Saline River

Tescott. The city was inundated and the water plant out of service for two or three days. The old wells were flooded, but the pump was saved. This was the seventh flooding within 60 days.

Barnard. The well field was flooded by a local creek, but that interruption of supply was not unusual.

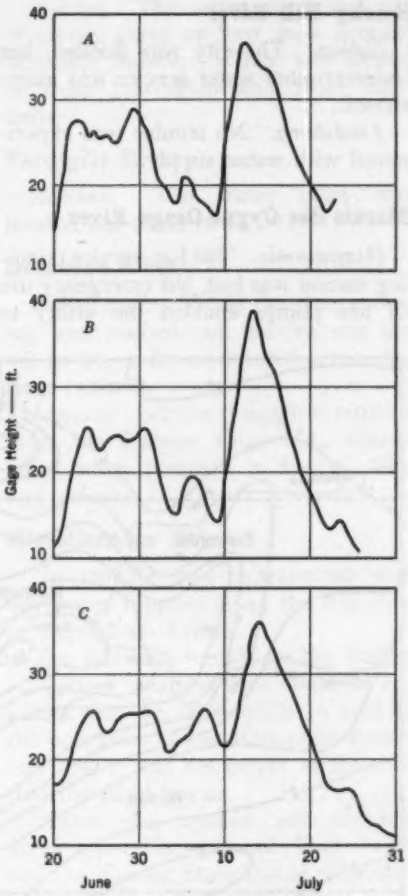

Fig. 4. Flood Hydrographs

Curve A shows variations in level of Kansas River at Topeka and Curve B at Bonner Springs. Curve C shows variations in level of Missouri River at Kansas City, Mo.

Smoky Hill River

Salina. The city was flooded, but uninterrupted water service was maintained.

Lindsborg. No trouble was experienced with water supply.

Marais des Cygne-Osage River

Osawatomie. The low-service pumping station was lost, but emergency use of fire pumps enabled the utility to maintain water service throughout the critical period.

Ottawa. The city water and light plant was completely flooded out of service. A U.S. Public Health Service pressure sand filter plant was set up by the Public Health Service and state board of health engineers, using an outboard motor for a flash mixer. This plant supplied drinking water to the city for twelve days.

Cottonwood-Neosho River

Chetopa. Doors and windows in the filter plant had to be sealed, but the plant was kept in service throughout.

Oswego. The filter plant was maintained in service, but the high- and low-service pumps were inoperative for four days.

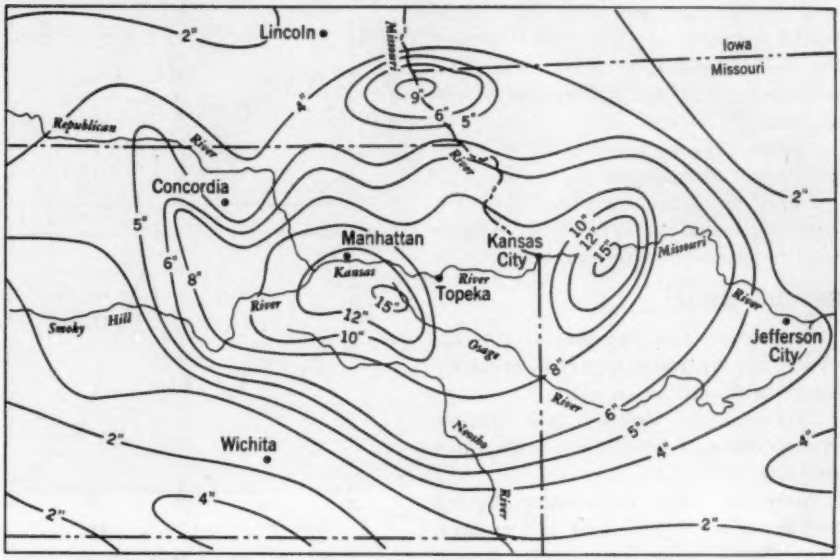

Fig. 5. Rainfall July 4–17, 1951

Isohyets show total rainfall in Kansas, southern Nebraska and western Missouri during period July 4–17. Maximum in flood area fell on Kansas, Osage and Missouri River basins, which comprised the most seriously affected area of the flooded regions.

St. Paul. The low-service pumps failed, but water was dispersed from the supply held in the elevated tank.

Erie. A temporary dike saved the water plant.

Chanute. The entire water plant was flooded out of service for seven or eight days for the first time in the

history of the town, although the area floods regularly. State board of health water purification units were flown in by the Air Force, as the city was completely cut off from land approach.

Humboldt. The low-service pumps were flooded and the clear well undermined or floated, but the plant itself was undamaged. There was no water service for six or seven days, during which time emergency treatment units, supplied by the U.S. Engineer Corps and operated by state board of health personnel, furnished potable water to the population.

Iola. The water and light plant was completely flooded out of service for six or seven days. The cities of Gas and LaHarpe which obtain water from the Iola plant, were also without water service for that time. Portable purification units loaned by the Army Engineers and erected and operated by state board of health engineers supplied drinking water during the shutdown.

LeRoy. Low-service pump motors had to be removed from service. Consumers had to conserve water, but there was no hardship.

Burlington. When the low-service pumps were flooded, the operator used a gasoline engine to pump the flood water through the plant. There was no service for one to two days.

Hartford. Both wells were cut out of service by flooding, but service was maintained from an elevated storage supply.

Emporia. No water supply trouble was experienced.

Strong City. The wells and plant were flooded out for four to five days.

Cottonwood Falls. Service was maintained by rationing the water held in elevated storage.

Marion. The water plant was out of service three or four days because of power failure. Water was hauled in from Herington and from farm wells.

Verdigris River

Altoona. The water plant was flooded out of service.

Delaware River

Valley Falls. When the river crossing was washed out, service was cut off, as the wells are located across the river from the town.

Lenexa. Service through a pipeline from the Kansas City, Mo., supply failed when pressure in Kansas City was reduced.

Miscellaneous Notes

No trouble was experienced with any water supplies along the Big Blue or Republican Rivers.

The fact that trouble on the Smoky Hill River was less than might be expected may be attributable in part to the operation of the Kanopolis Reservoir, but it was not empty at the time that the flood began.

Water was trucked into stricken areas from Garnett and Fort Scott, and the Kansas State Board of Health operated temporary filter plants stationed at Ottawa and Johnson County —pressure sand units—and at Chanute, Iola, Humboldt and Neosho Falls —diatomaceous earth units. The Missouri National Guard also had two diatomite units set up in the Johnson County suburbs of Kansas City.

The flood that developed in Kansas was also the cause of flood in Missouri and Oklahoma, but rather than attempt to present the whole picture here, the Kansas experience has been taken as representative.

Summary

Like the New York metropolitan area water shortage a couple years ago, the Kansas flood has placed dramatic emphasis on the need for a sound national water policy. Whether sound policy or sound politics will dictate the action eventually taken remains to be seen. Be that as it may, the foregoing water supply notes have indicated at least three possibly significant points.

1. A very large number of plants were crippled by power failures. Whether this was the result of vulnerability of the power supply as a whole or of the specific installation affected is not now known, but the entire matter of power supply and auxiliary power for emergencies will bear a great deal of investigation.

2. Elevated storage proved to be valuable to many communities that were unable to keep their systems in operation. By rationing the supply available in storage, many were able to take care of themselves without outside assistance until the regular water service could be restored.

3. The fact that so many water plants and clear wells, which could have been built out of the river valleys for a small additional cost, were under five to ten feet of water suggests that designing engineers and regulatory bodies responsible for approving water works plans may want to reexamine their plant location policies.

Correction

In the paper "Furnishing Chicago Water to Outlying Municipal Districts" by Loran D. Gayton, which appeared in the July 1951 JOURNAL, the numbering key to Fig. 1 on page 540 became scrambled. The correct key follows:

1—Mayfair Pumping Station
2—Thomas Jefferson Pumping Station
3—Lake View Pumping Station
4—Springfield Ave. Pumping Station
5—Chicago Ave. Pumping Station
6—Cermak Pumping Station
7—Central Park Ave. Pumping Station
8—14th St. Pumping Station
9—22nd St. Pumping Station
10—Western Ave. Pumping Station
11—68th St. Pumping Station
12—South District Filtration Plant
13—Roseland Pumping Station

Meter Maintenance Costs

By A. P. Kuranz

A paper presented on April 30, 1951, at the Annual Conference, Miami, by A. P. Kuranz, Mgr., Water Utility, Waukesha, Wis.

TO survey meter maintenance practice in cities in the United States having populations from 100,000 to 200,000, a questionnaire was sent to the 56 cities that are in this group. That 40, or 71.4 per cent, of the total completed the questionnaire indicates that there is a vital interest in this subject. The questionnaire consisted of twenty main questions and subquestion groups, and covered all known aspects of a meter maintenance program.

The survey was devoted to $\frac{5}{8}$-in. displacement meters only, because 91 per cent of all meters manufactured and sold to water works are of this size, and whatever is true of the $\frac{5}{8}$-in. size is very likely valid for all displacement types.

Since the author conducted a similar survey (1) of the same population group of cities, in addition to sixteen Canadian cities with populations between 32,000 to 639,000, in 1941, what is being presented is actually a progress report on meter maintenance practice. A comparison of the earlier report with the results of the present survey indicates that decided progress has been made in the past ten years.

Questions and Answers

1. *What proportion of new meters are tested before being placed in service?*

Meters Tested	Cities
All	30
From 1 to 25 per cent	2
None	8

1a. *What is the lowest flow at which meters are tested?*

1b. *What accuracy is demanded at that flow?*

Rate of Flow *gpm.*	Accuracy Demanded *per cent*	Cities
$\frac{1}{8}$	Indicates movement–90.0	2
$\frac{1}{8}$	90.0–99.0	1
$\frac{1}{4}$	90.0–102.0	19
$\frac{1}{2}$–1	80.0–101.5	2
1–3	99.5–100.5	4
8–20	90.0–98.0	2
$\frac{1}{32}$-in. orifice		2
No reply		8

An increasing number of water works are demanding accuracy at low rates of flow, thus evidencing good management.

2. *Has the method of removing a meter after it has registered a certain amount of water been adopted?*

Reply	Cities
Yes	12
No	26
No reply	2

It appears that more attention is being paid to methods of determining when a meter should be tested, rather than accepting the amount of water

passing through it as a standard. From the replies to Question 3, it will be seen that more than 50 per cent of the cities have adopted a time limit for removing a meter.

3. *Has the method of removing a meter after it has been in service a certain period been adopted?*

Reply	Cities
Yes	22
No	16
No reply	2

4. *If a combination of the two methods mentioned in Questions 2 and 3, or any other method, is followed, please explain.*

The replies, of course, were that procedure was based upon a combination of the amount of water measured and the years in service.

Analysis of Question 4 develops into a summary of Questions 2 and 3. Some replies stated that working conditions of the meters themselves is a determining factor in addition to an examination of the meter readers' books. A few meters are removed for test on complaints from customers. The important fact is that the meter is not installed and then just forgotten as happened formerly.

5. *Are meters removed in a certain section of the city, such as streets, wards or some other division? If so, please explain.*

Removal	Cities
By streets	1
By wards	3
By zones or districts	3
No divisions	22
Owner owns meter	1
No reply	10

No geographical divisions are observed by 50 per cent of the cities in removing meters, a fact which further indicates that the meter itself is the important unit, and that the water works has developed its plan around it.

5a. *Is the selective manner followed? If so, please explain.*

There were 27 answers to this question, of which 20 indicated that the operation of each meter is watched very closely. Any change in registration is assumed to indicate that the meter is due for repair.

6. *How much time is required to bring a meter into the shop?*

Time *minutes*	Cities
12–30	17
30–60	9
60–90	1
Depends on distance	1
Charges 2 hours to customer	1
No reply	11

The majority indicated that approximately 30 minutes is required to bring a meter into the shop. Many water works have apparently adopted a plan of collecting several meters in one pickup.

7. *Are all meters tested as they are brought into the shop for testing and repair?*

Meters Tested	Cities
All	32
Proportion of total	1
No reply	7

7a. *If the answer is "All," what is the lowest flow at which they are tested?*

Rate of Flow *gpm.*	Cities
$\frac{1}{8}$	1
$\frac{1}{4}$	19
$\frac{1}{3}$	2
$\frac{3}{10}$–2	6
3–5	2
18	1

Rate of Flow gpm.	Cities
$\frac{1}{32}$-in. orifice	2
$\frac{1}{4}$-in. orifice	1
No reply	6

The water works is obviously quite interested in checking accuracy since the meter was last in the shop. Half of these meters are tested on a $\frac{1}{4}$-gpm. flow.

8. *Are all meters taken apart completely?*

Disassembled	Cities
All	29
None	9
Not if passed by test	2

a. *If only part of the meter is disassembled, which part is it?*

This question was poorly developed, as was evidenced by varied answers. The replies did indicate, however, that the meter repair shops are interested in doing a good job by doing perhaps more work than is absolutely necessary.

9. *What method of cleaning the disc chamber is used?*

Cleaning Method	Cities
Abrasives (brush, scraper, steel wool, emery cloth, sand paper, abrasive powder); no solvent	14
Above abrasives plus some solvent	23
Solvent only	3

The answers all point to the fact that the chamber is really the heart of the meter, and upon its repair and cleaning depends the accuracy of the meter.

10. *Are registers found in need of repair in the usual repair program?*

Registers Defective	Cities
Yes	27
Some	3
No	10

10a. *If the answer is "Yes," is the register repaired or it is replaced with a new one?*

Register Renewal	Cities
Repair	28
Replacement	2
Repair if possible; replacement if necessary	4
No reply	6

The answers indicate that the registers do need repairs, and that most of the utilities repair rather than replace them. As the nature of the necessary repairs was not inquired into, little detailed information was obtained.

11. *Are gear trains repaired by putting in individual gears?*

Single Gears Replaced	Cities
Yes	36
No	4

11a. *Are gear trains repaired by putting in complete new ones?*

Gear Trains Replaced	Cities
Yes	21
No	11
Only when necessary	3
No reply	5

This is another poorly posed question, and the answers seem to indicate that it is redundant. Most meter repairmen stated that they would rather repair gear trains by replacing individual gears.

12. *Is the register set back to zero?*

Register Reset	Cities
Yes	27
Not always	1
No	12

Almost 70 per cent of those answering stated that the registers were reset to zero. From the comments made, it appears that many water works con-

sider the meter practically new after repairs.

13. *Are meters tested after they are repaired?*

Tested After Repair	Cities
Yes	40

a. *If "Yes," what is the lowest flow in gpm. at which they are tested? What accuracy is demanded at the lowest flow?*

Rate of Flow *gpm.*	Accuracy Demanded *per cent*	Cities
¼	60–98*	26
½	90–95	2
½–2	80–102	7
3–8	98–100.5	2
3/32-in. orifice	90–98	2
¼-in. orifice	98–102	1

* Almost all using more than 90 per cent.

Question 13 was answered affirmatively by all cities, and it is interesting that these tests were made on low rates of flow. The accuracy demanded is also high, which evidences the same trend that has been prevalent throughout the entire survey.

14. *How much time per meter is required to do the work mentioned in Questions 6–13?*

Time Required *hours*	Cities
½–1	10
1–2	13
2–3	6
3–4	1
Depends on meter condition	1
No reply	9

Almost 60 per cent of the answers indicated a maximum of 2 hours to prevail throughout this size city. The size of the test bench itself undoubtedly had considerable effect on these figures.

15. *What is the yearly cost per meter for repair parts alone?*

Cost *dollars*	Cities
0.046–0.50	19
0.51–0.75	4
0.76–1.00	2
1.00–1.75	2
No data kept	3
No reply	10

Approximately 50 per cent keep the cost of repair parts within a 50¢ per year per meter limit. This figure is undoubtedly based upon past years' prices of repair parts, so current figures would probably be higher.

16. *At what cost for repair parts only—in relation to the cost of a new meter—is it considered uneconomical to repair a meter?*

Portion of Meter Cost *per cent*	Cities
10	1
25–33.3	4
40	1
50–75	16
80	1
Never junk meter unless case is damaged	1
Never junk any meter, use all good parts	2
No reply	14

There were many comments which perhaps can be summed up best by stating that much depended upon the individual meter repair shop personnel. Some were even willing to spend considerable money in repair parts to keep old meters in operation. Some commented that difficulties in obtaining repair parts during recent years causes them to spend more time and, therefore, keep a meter longer.

17. *At what cost for labor only—in relation to the cost of a new meter—is*

it considered uneconomical to repair a meter?

Portion of Meter Cost *per cent*	Cities
12–25	11
30–50	5
60–80	4
90	1
Repair all meters, regardless of cost	3
No reply	16

Here were found varied responses which indicate that many utilities have not yet decided upon the proper procedure to be followed in resolving this factor.

18. *At what cost for labor and repair parts—in relation to the cost of a new meter—is it considered uneconomical to repair a meter?*

Portion of Meter Cost *per cent*	Cities
15–40	3
50–75	17
80–90	7
Repair all meters, regardless of cost	3
No reply	10

The comments made on Question 17 also apply to the answers to this question.

19. *What proportion of customers' services are metered?*

Services Metered *per cent*	Cities
100	27
90–99.6	6
80–90	1
60	1
12–33.3	2
.068–1.5	2
No reply	1

Almost 70 per cent of the cities are completely metered, and only a few are less than 90 per cent metered. This situation augurs well for the efficient operation of water works. In some cities that reported, residential meters are prohibited by ordinance, a situation which may explain the lower proportions recorded.

20. *What proportion of production is accounted for through meters?*

Production Metered *per cent*	Cities
95–100	2
90–95	7
85–90	13
80–85	8
60–80	3
Less than 50	2
Unknown	2
No reply	3

The answers received to this question are perhaps more important than any others. They indicate that 55 per cent of the water works in cities of the size surveyed account for more than 85 per cent of the water pumped, and that another 20 per cent account for more than 80 per cent—a total of 75 per cent account for more than 80 per cent of their water.

Summary

The survey indicates that water works managers are keenly interested in the proper operation of their utilities since they are so concerned with the maintenance of their meters, the cash registers of the water works.

Comparison of this study with the survey made in 1941 will show that the progress made in the last ten years has been outstanding. The men who are responsible for this activity are to be complimented.

Reference

1. Kuranz, A. P. Survey of Meter Maintenance Practice. Jour. A.W.W.A., **33**: 1381 (Aug. 1941).

Seasonal Water Demands in Vacation Areas

By S. K. Keller

A paper presented on May 3, 1951, at the Annual Conference, Miami, by S. K. Keller, Gen. Supt., Pinellas County Water System, Clearwater, Fla.

AT the suggestion of the Chairman of the A.W.W.A. Publication Committee, a questionnaire was sent to representative water departments in each district in Florida, a region that was expected to feel the greatest effect of seasonal water demand in vacation areas. It was anticipated that the answers to this questionnaire would lend themselves to a simple tabulation which would identify a definite vacation period in Florida, and show its exact effect in demand on the water systems of the various cities.

The response was generous, but the information received was entirely different from that which was expected. Complex problems exist which will require considerable study and further investigation before answers are found.

The author has noticed that in the lower west coast district, there is now no period of the year when out of state cars disappear from the streets entirely. This situation suggests the possibility that more vacationists are traveling south in the summer. The short winter season, during which water systems operate peak load equipment at top capacity, followed by a long period of idleness may no longer exist. In the future, there may be a trend toward longer seasons with a more evenly divided load and a shorter period of equipment idleness.

In Florida, lawn sprinkling also appears to have more effect upon the demands on the water systems than was at first thought. Time did not permit a thorough examination of rainfall data in the various areas, and therefore, only a few observations of this factor could be made.

Lower East Coast

The lower east coast region of Florida, with Miami, is known all over the world as a favorite vacation area. The report received is for the city of Miami only and does not include Miami Beach, Coral Gables, Hialeah or Miami Springs, which are wholesale customers of the city:

> The Greater Miami [vacation] season was once considered to include January, February, March and sometimes April, depending upon the advent of Easter. The season now seems to begin in November and extend through April. However, the area has been experiencing a very heavy influx of tourists during the summer months, so that although the quantity of water pumped during a month may be less than a so-called seasonal month, there are days during which the water pumpage approaches the demand experienced during the season.

Increase of Peak Load

To the question of what the proportion of increase in the seasonal peak load is above normal consumption, the reply was that:

> This question presupposed there is a period during which only permanent residents are using water. But, as was pointed out, there is no such period, and

therefore, the only way to answer is to give the per cent difference between the six months' periods assumed as seasonal and normal for one value, or to pick a peak month during the season and to compare it with a month during the summer period for another value. The 1949–50 fiscal period indicated the following:

Six Seasonal Months	9.34 bil. gal.
Balance	8.30 bil. gal.
Increase	12.6 per cent

For the fiscal year 1948–49:

Seasonal Months	9.34 bil. gal.
Balance	7.34 bil. gal.
Increase	27.2 per cent

If the water pumped during March 1950 is compared with that pumped during October 1949 the following relationship is found:

March 1950	1.68 bil. gal.
October 1949	1.24 bil. gal.
Increase	35.4 per cent

It must be remembered that October is a rainy month and the sprinkler load is therefore down.

The average peak load begins at 8:00 A.M. at 70 mgd., rising steadily to a morning peak of 87 mgd. at 10:00 A.M. It then drops to a low of 78 mgd. at 2:00 P.M. At 3:00 P.M. the rise starts again to a peak of 92 mgd. between 6:00 and 7:00 P.M., then declines to 60 mgd. at 9:00 P.M., with an average load of 81.64 mgd.

The estimated sprinkler load is 20 per cent of daytime demand, particularly during the winter months, which comprise the dry season. Actual 24-hour consumption drops have reached 12 mil.gal. It will, of course, reduce the pumping rates which are indicated above.

Miami Per Capita Use

For a comparison of the per capita use during peak seasons and slack seasons, Miami reports that the permanent population using water is 347,462. It is improbable that this number is not augmented by tourists during the slack season. There are approximately 200,000 visitors during the peak of the season, making the population at that time approximately 547,000. If the March 1950 figure is indicative of a peak month, then the consumption during the season is 99 gpcd. (including sprinkler load). If October 1949 is an off-peak month, then the use is 115 gpcd.

Because of a constant labor force and a sliding scale rate for electric power, the cost of production of water per unit decreases as the peak load increases. At present the peak load equipment is idle at least half the time. It is also estimated that 20 mil.gal. of storage is required to meet peak loads.

The cost of production, including treatment, based on the amount pumped, is 6.922¢ per 1,000 gal. There is approximately a 10 per cent loss which raises the cost to approximately 7.7¢ per 1,000 gal. on a basis of water sold.

Comparison With Smaller Systems

For comparison with Miami, the effect of peak loads on a smaller water system has been studied. The city of North Miami offers an example of the phenomenal growth which some of the vacation areas in Florida are experiencing. Building permits are issued for twelve to fourteen million dollars of new construction annually. As a result of this growth, additions to the water department may not be keeping pace with the demand, and the effects of vacation peak loads are not clearly defined.

The peak loads begin in December and end in May, with an apparent 50 per cent increase in demand over normal. The peak load hours are practi-

cally the same as in Miami. There is an abrupt drop in demand when the spring rains begin in March of about 25 per cent, which evidently represents the proportion of peak load that is used for lawn sprinkling. The average consumption is 300 gpcd., which is excessive in comparison to Miami. Lawn sprinkling may be higher than the average.

To show to what distance inland the effect of coastal vacation seasonal demands are felt, the cities of Tampa, Clearwater, Pinellas County Gulf Beaches, St. Petersburg and Bradenton —all in the southwestern portion of Florida known as the Tampa Bay Area —have been studied.

Tampa is located at the head of Tampa Bay in Hillsborough County, approximately 25 miles from the Gulf of Mexico. It is a manufacturing and distributing center and is also the site of the MacDill Air Force Base.

Figures submitted by the Tampa Water Dept., indicate that the tourist season does not have any appreciable effect on peak load demand, as the seasonal peak loads occur during April and May, and are almost entirely due to lawn sprinkling. The average peak load begins at 4:00 P.M., at approximately 37 mgd. demand, with an abrupt rise at 5:00 P.M. to a demand of 45 mgd., and another peak load rise at 6:00 P.M., with a maximum peak load demand of 50.5 mgd. This demand lasts until 7:00 P.M., then slacks off at approximately the same rate as the rise, reaching normal at 9:00 P.M.

The peak loads which occur in the months of April and May, with an average of 25 per cent over normal, come just before the beginning of the summer rain season. During normal months, consumption is estimated to be 100 gpcd. and 150 gpcd. for the peak load demand.

The economical limit of storage, to supply the various demands, is 10 mil.gal., half from elevated tanks and half from ground storage. Peak load equipment is estimated to be idle 25 per cent of the time.

The variation in seasonal demand seems to have little effect on the cost of production as a single plant is used and the same labor crew is maintained throughout the year, with all other operating expenses remaining constant.

The total cost of production, including depreciation but not debt service, was 15.3¢ per 1,000 gal. for the fiscal year ending September 30, 1950.

Clearwater

Clearwater, situated on the Gulf of Mexico, due west of Tampa, is located on an island and on the mainland of Pinellas County. It is the seaside resort for Tampa, as well as a vacation center.

The records show there are two peak load seasons. One occurs during January and February, with an increase of 80 per cent over normal. This can be considered as a combination of the effects of tourists and lawn sprinkling. There is a drop in March to 46 per cent above normal. Then another peak load period of 80 per cent above normal occurs during April, May and June. During July the consumption drops back to normal.

The months of April, May and June are usually dry, with summer rains starting in July. The second peak load, therefore, can only be due to lawn sprinkling. In view of these factors, the seasonal peak load due to the tourist travel can be assumed to be approximately 50 per cent over the normal load.

The 24-hour demand curve is well defined. The peak load starts at 3:00 P.M., increases slowly until 6:00 P.M.,

then increases rapidly, with the heaviest demand from 7:00 to 8:00 P.M. There is a heavy decrease until 9:00 P.M., and normal demand again at midnight. Approximately 30 per cent of the load during the tourist season is attributable to lawn sprinkling.

The estimated annual per capita use is at the rate of 100 gpcd., and the cost of production remains practically the same. The economical limit of storage to meet peak load demands is 2 mil.gal.

Pinellas County System

The Pinellas County water system serves mainly the islands along the Gulf Coast of Pinellas County, from Belleair to Pass-a-Grille. It is used as an example of a smaller system serving an area which is entirely vacational.

The system is comparatively new, having been placed in service for the first time in 1937. It has experienced the same difficulties as that of North Miami, where the rental units and population have grown tremendously during the past five years.

Originally, there was a sudden 100 per cent increase in peak load during February and March, a sudden drop to normal, then a slight increase in July and August and a return to normal during the balance of the year.

During 1950 and the present season, however, the picture has completely changed. The winter vacation period begins in December, increasing to a peak load in February and March of 60 per cent over normal. Then demand gradually drops to normal by July 1. The summer vacation period begins in July, increases to a peak load in August of 25 per cent over normal, and then abruptly drops to normal after Labor Day. In this period, rainfall was normal; lawn sprinkling was at a minimum and did not exceed 15 per cent. The estimated use during peak seasons is 90 gpcd. and for normal is 110 gpcd.

The 24-hour demand curve shows the peak load begins at 3:00 P.M. with a normal of 600 gpm., rises to a maximum of 1,400 gpm. at 6:30 P.M., remains constant to 8:30 P.M., then gradually decreases to normal at 11:00 P.M.

The economical limit of storage to meet peak loads is 1.7 mil.gal., elevated, and 0.3 mil.gal., ground. The peak load equipment is idle 40 per cent of the time. Under these conditions, the unit cost of production decreases during peak loads to an average of 11¢ per 1,000 gal., including booster pumping.

St. Petersburg

St. Petersburg, located on Tampa Bay, in the southeastern part of Pinellas County, has a large number of winter vacation visitors. In the absence of a returned questionnaire, press reports were consulted and found to indicate that the peak load begins in December and ends in April, with a 60–70 per cent increase in demand. In addition, the same source indicates that there are a considerable number of private wells used for lawn sprinkling, because of the rather high cost of city water. The proportion of water used for lawn sprinkling should therefore be very low. This information is entirely unofficial and is used only as a comparison for the area.

Bradenton

Bradenton, located in Manatee County, at the southern end of the Tampa Bay area, attracts many visitors.

The vacation period begins in the latter part of December and ends in April, with a peak load demand of 30 per cent over normal. There is an-

other peak load during the months of May and June, amounting to 24 per cent over normal. As these months just precede the usual rainy reason, it is assumed that this peak is due mainly to lawn sprinkling.

The average cost of production is 6.4¢ per 1,000 gal., which decreases to 5.3¢ during the winter peak load. No additional information is available.

Orlando

Orlando, located in the central part of Florida, is the largest inland city. It is a distributing center for the surrounding community and also for some of the western and southwestern parts of Florida. Many industries are served by the municipally owned Orlando Utilities Commission. The city also enjoys a large tourist business during the winter season.

It was originally estimated that Orlando would have a peak load demand for water during the winter season. A report from its water department, however, indicates the seasonal peak loads to be in May, June and July, with a 50 per cent peak over normal consumption. Nearly all the peak load during those months is attributed to lawn sprinkling, the average peak load beginning at 2:00 P.M. and ending at 6:30 P.M., with a sharp drop back to normal at 9:00 P.M.

The peak load month is June. Whereas the average consumption during normal months is 146 gpcd., during June consumption rises to 196 gpcd.

The economical limit of storage to supply various demands is reported to be 7 mil.gal., and peak load equipment is idle half the time.

Because costs and the number of personnel required to operate the plants are fixed, the cost of production rises during the normal load. The cost of water produced at normal load is 6.55¢ per 1,000 gal. and decreases to 6.49¢ during the peak load month. These figures include all pumping, treating and maintenance costs for water delivered to the consumer.

Daytona Beach

Daytona Beach, located in northeast Florida on the Atlantic Ocean, is noted as one of the vacation cities of that area. The tourist season starts in December and extends continuously through the spring and summer, to include August. The heaviest load months are June, July and August, with a peak demand 49 per cent above normal. There is a lesser peak vacation demand in March. Apparently the city is considered a summer rather than only a winter resort.

The effect of lawn sprinkling on the peak demand is hard to estimate because rainfall is irregular. In 1949 the monthly demand decreased 6 mil.gal. from May to August, while during the same period the rainfall increased steadily from 1.40 in. to 11.46 in. per month. From June to August of 1950, however, the monthly demand decreased the same amount—6 mil.gal.—while the rainfall also decreased from 6.45 to 3.88 in. The 1949 results were as would be expected, showing a decrease in demand with an increase in rainfall. The 1950 results, however, showing a decrease both in demand and rainfall, are a little hard to understand without further investigation.

Consumption is estimated at 83 gpcd. in peak seasons, and 113 gpcd. during slack seasons.

The economical limit of storage required is 2.85 mil.gal. in standpipes and 0.475 mil.gal. in elevated tanks. The average cost of production is 16¢ per 1,000 gal.

Conclusions

From the above reports, it is possible to draw a few conclusions about the effect of seasonal water demand on water systems in vacation areas.

1. The period of heavy demand in Florida begins during the latter part of December for all sections.

2. The winter season demand is of shorter duration in the Tampa Bay area than in the lower east coast near Miami.

3. The water systems experiencing the heaviest demands are those serving the coast or immediately adjacent area, as is illustrated by the Tampa report.

4. Northeast Florida apparently has a heavier summer vacation demand, as is evidenced by the Daytona Beach report.

5. The increase in demand during peak loads varies almost inversely with the size of the water system:

Pinellas County	60 per cent increase
Clearwater and North Miami	50 per cent increase
Daytona Beach	49 per cent increase
Miami	19 per cent increase (average)

6. The per capita demand is between 20 and 25 per cent less during peak load than during normal slack load.

7. The characteristics of the 24-hour demand curve appear to be practically the same for all areas in Florida, regardless of the size of the water system.

Apparently local conditions and methods of operation of the various water systems determine the economical limit of storage required to meet peak loads and the time the peak load equipment is idle.

9. The production cost per 1,000 gal. is less during peak load season than for slack seasons, following the rule that greater production reduces the cost per unit. The degree to which the rule applies appears to be influenced by two factors: the use of the same organization throughout the year and the sliding power rates which enable water systems to get into lower cost brackets during peak load seasons.

There is no general information on the proportion of peak loads caused by lawn sprinkling, except in Tampa and Orlando, where the peak loads are apparently during dry periods.

It is felt that there should be much more investigation of this situation in all vacation areas in this country. Such studies would establish a comparison of the various types of vacation areas, and thereby disclose more conclusive data.

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Discussion

Maurice Brunstein

Supt. and Engr., Water Dept., Atlantic City, N.J.

The author has done an excellent job of assembling the very interesting information contained in his paper. He has presented data gathered from different vacation areas in Florida, each with apparently dissimilar conditions. Yet all the areas showed the same definite trend and confirmed the conclusion

that the resort visitor creates a challenging problem for the water department in the community in which he becomes a transient resident.

New Jersey Resorts

Conditions in the resort areas in New Jersey are very like those in Florida and although they occur at a different time of the year, the resulting problems and their effects closely parallel those reported in Florida. The Atlantic City water system, for example, has a widely varying demand. Its pumping rate varies from a low of 4.5 mgd. on winter nights to 28.0 mgd. on peak summer days.

In 1950 the average pumpage was 10.56 mgd., which indicates a consumption of 170 gpcd. on the basis of the permanent population only, or 124 gpcd. for an estimated average population of 85,000 for the year. The pumpage for the minimum day was 7.5 mil.gal. and the maximum day was 7.1 mil.gal.—the maximum rate of pumping, however, was 28.0 mgd. The total pumping capacity in regular service is 40 mgd. and there are also gasoline-engine-driven pumps of 33-mgd. total capacity, installed for standby service (Table 1).

The four electric-motor–driven pumps are put on and off the line in varying

TABLE 1

*Atlantic City Pumping Units**

Pump No.	Output *mgd.*	Head *ft.*	Power *hp.*	Speed *rpm.*	Type	Year Installed
1	2.5	115	60	1,765	Induction†	1947
2	7.5	110	200	1,200	Synchronous†	1946
3	13.0	115	300	900	Synchronous†	1936
4	17.2	115	400	900	Synchronous†	1936
5	11.0	128	312	1,285	Gasoline‡	1947
6	11.0	128	312	1,285	Gasoline‡	1947
7	11.0	128	312	1,285	Gasoline‡	1947

* All units have DeLaval pumps.
† General Electric motor.
‡ Buffalo engine.

To supply Atlantic City, water from ponds and wells is pumped approximately 6 miles across the meadows from the mainland to the city, which is located on Absecon Island. There are two transmission mains, both of 48-in., Class B, cast iron, except for one-half mile of 48-in. wood-stave pipe with wrought-iron bands still in service.

Since the two standpipes in the city have a combined storage capacity of but 500,000 gal., a direct pumpage system that operates continuously is necessary. The normal operating head at the pumping station is 110 ft.; discharge pressure is 45–47 psi.

combinations throughout the day, to furnish the quantity of water needed. Close adjustment is obtained by throttling the pumps, which wastes some power. The amount of power wasted varies from day to day, and depends upon how near to full capacity the pumps can be operated to meet changing demands. By careful operation, this waste is held down to an average of approximately 8 per cent, or $1,600 per year, based on an average yearly high-lift power consumption cost of $20,000 at 1¢ per kwh. The construction of a 1-mil.gal. elevated tank is contemplated, to provide more storage

and to improve pumping conditions and pressures.

The highest pumpage in the history of the water department was at the rate of 31.0 mgd. on August 9, 1930. The largest fire on record was December 4, 1943 (Boardwalk and Maryland Aves.). It increased the pumpage at the peak of the fire by a rate of 8.5 mgd. and required approximately 1.8 mil.gal. during a 10-hour period.

Auxiliary Fire System

It may be of interest to describe the auxiliary high-pressure fire system. A 20-in. high-pressure main runs under the boardwalk for a distance of approximately 1¼ miles from Arkansas to Massachusetts Avenues, with 12-in. lateral mains extending north on side avenues to supply 110 special hydrants. Six boardwalk hotels maintain steam or electric power plants and special fire pumps which take the water from the mains of the municipal distribution system at 42-psi. pressure and boost it to 150 psi. upon receiving an alarm signal that there is a fire in the high-pressure area.

This system was a mutual undertaking by some of the beachfront hotels and the municipal authorities. The hotels paid for, installed and maintain the pumps; the city laid and maintains the high-pressure mains and connections. Most of the hotels have their own private wells and have installed emergency connections from the wells to the high-pressure pumps. The combined capacity of all the high-pressure pumps is 10.5 mgd. at 150-psi. pressure.

It might be interesting to note that some of the peak loads are due to sudden summer showers which send thousands of people home from the beaches at the same time. They take baths or showers, thereby creating a sudden demand for water that must be met by the pumps. The operators have always been alert to the varying demands, and handle these peak load conditions most capably.

H. T. Critchlow

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New Jersey has a coastline of 125 miles on the Atlantic Ocean, between Atlantic Highlands on the north and Cape May on the south. This coastline has an almost continuous strip of white sand beaches, making it an ideal vacation area. Along it are 81 municipalities supplied by 52 separate water supply systems. The two largest systems obtain their water supply from a combination of surface streams and artesian wells. The rest depend upon deep wells for their water. The average consumption for all of the systems in 1950 was 40.36 mgd. The maximum monthly consumption was 65.66 mgd. during August, about 63 per cent above the annual average. The permanent population of this territory is 317,190 while the maximum summer population is estimated at 946,410—a threefold increase.

Fourteen of the water systems use 1 mgd. or more each, with an annual average of 31.80 mgd. in 1950 and a maximum month (July) of 53.14 mgd., which is approximately 67 per cent above the annual average. A few comments are made on some of the larger water systems shown in Table 1.

Atlantic City

The water works system for Atlantic City obtains its supply from deep wells and a surface reservoir on Absecon Creek, located six miles west of

the city, near Pleasantville. The average annual consumption in 1950 was 10.56 mgd., with 17.1 mgd. in the maximum month (August), or an increase of 61 per cent. Consumption based upon the permanent population of 61,642, is 170 gpcd.; based upon the maximum population of 125,000, it is 136 gpcd. During certain weekends, the consumption and the population may be twice these amounts.

It should be mentioned that a number of the large hotels in Atlantic City and vicinity (approximately eighteen) obtain their water from private wells, tapping the so-called 800-ft. Atlantic City horizon on the beach. The production of these wells is about 14 mgd. during the summer and approximately 6 mgd. during the winter. These amounts are taken in addition to the water obtained from the municipal water supply systems.

Monmouth Consolidated Water Co.

The Monmouth Consolidated Water Co. supplies 21 municipalities along the north Jersey coast, between Long Branch and Ocean Grove. The principal source is a reservoir on Swimming River near Red Bank. This supply is supplemented by deep wells at the southern part of the territory served. The average annual consumption in 1950 was 8.08 mgd., with a maximum monthly consumption of 12.26 mgd. in July, representing an increase of 52 per cent. Consumption based upon the permanent population of 97,200 is 83 gpcd.; based on the summer population of 199,800, it is 61.3 gpcd.

Asbury Park

The Asbury Park water system supplies only the portion of the city east of the Long Branch Railroad—approximately one-half. The western portion is supplied by a private water company. The municipal plant obtains its water from wells that are approximately 1,100 ft. deep. The average annual consumption in 1950 was 1.85 mgd., with a maximum monthly consumption in July of 2.92 mgd., or an increase of 58 per cent. Consumption based on the permanent population of 8,000 is 231 gpcd.; based on the summer population of 50,000, it is 58 gpcd.

City of Wildwood

The city of Wildwood obtains its supply from deep wells, some of which are on the mainland about five miles west of the city, and others on the beach within the city. The average annual consumption was 1.64 mgd. in 1950, with a maximum monthly consumption of 4.14 mgd. in July, or an increase of 152 per cent. Consumption based upon the permanent population of 14,000 is 117 gpcd.; based upon the maximum summer population of 150,000, it is 27.5 gpcd.

Cape May

The city of Cape May obtains its water supply from deep wells within and just to the northwest of the city. The annual average consumption was 1.03 mgd. in 1950, with a maximum monthly consumption of 1.86 mgd. in July, or an increase of 81 per cent. Consumption based upon the permanent population of 3,500 is 294 gpcd.; based upon the maximum summer population of 8,000 it is 233 gpcd.

Ocean City Water Service Co.

The Ocean City Water Service Co. obtains its supply from wells in the 800-ft. Atlantic City horizon within the city. The average annual consumption in 1950 was 1.04 mgd., with a maximum monthly consumption of 2.73 mgd., or an increase of 152 per cent.

Consumption based upon the permanent population of 6,000 is 173 gpcd.; based upon the maximum summer population of 80,000, it is 34.2 gpcd.

Summary

It is noted that the water supply systems supplying the New Jersey cities on the Atlantic coast have their peak demands in July and August. The largest increase in summer consumption occurs in cities which are almost entirely of the resort type, such as Asbury Park, Wildwood and Ocean City. The ratio of peak to average demand is less for the larger systems, like that of Atlantic City and the Monmouth Consolidated Water Co., reflecting the demands of business and industrial development throughout the year.

All of the systems depend upon pumping stations to deliver the water from the source of supply into the distribution system. This situation requires considerable reserve capacity in pumps. The only storage facilities other than standpipes, which are common to all of the systems as balancing reservoirs, are the surface reservoirs for Atlantic City and the Monmouth Consolidated Water Co.

Salt water contamination is another problem faced by water supplies in coastal areas. New Jersey has legislation directed toward the control of diversion in certain parts of the state where excessive use may endanger the available subsurface supply by overdraft or intrusion of salt water. These dangers may be increased by the surge created in water-bearing formations near the coast by peak seasonal demands in resort areas.

TABLE 1

Seashore Consumption

Supply	Annual Avg. *mgd.*	Max. Month		Ratio Max. Month to Ann. Avg. *per cent*
		July *mgd.*	Aug. *mgd.*	
Asbury Park	1.85	2.92		158
Atlantic City	10.58		17.10	161
Belmar	1.33	1.99		150
Cape May (City)	1.03	1.86		181
Keansburg	1.04	1.74		167
Margate	1.07		2.05	192
Monmouth Consolidated Water Co.	8.08	12.26		152
Ocean City	1.04		2.73	252
Point Pleasant and Beach	0.98	1.72		175
Red Bank	1.32		1.66	126
Seaside	0.65	1.48		229
Ventnor	1.18		2.07	176
Wildwood	1.64	4.14		252

By Alfred H. Fletcher

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In preparation for a discussion of this paper, the New Jersey State Dept. of Health made a survey of approxi-

mately fifteen summer resort municipalities along the Atlantic coast of the state. This survey represents a summer population of more than 1,500,000 people, including Atlantic City. The survey shows that more than one-half of these municipalities are exceeding the safe yield of the wells which supply their water.

The overall estimated peak summer population is almost five times the winter population, although the overall water consumption during the summer months is only approximately twice that of the winter season. All of these water supplies are supervised by operators licensed by the State Dept. of Health.

Gearing Operations

With such wide variations in water consumption between the winter and summer seasons, it might be expected that some communities would gear their plant operations to the nine-month winter season rather than to the three-month summer season. This, however, is not true, partially because of a New Jersey law requiring all water works operators to be licensed, and partially because of the close control exercised in past years over the public water supplies by the state department of health.

The bacteriological samples taken on a quarterly basis each year are satisfactory. It is not possible to separate the problems of water quantity and water quality when dealing with safety and public health. It is the responsibility of the health department to prevent the contamination of a supply while using an emergency source of water on a temporary basis and when operating with a shortage. Such conditions may be responsible for back siphonage caused by failures in pressure and also create acute problems in homes and apartments that cannot and must not be tolerated.

The state department of health plans to give special consideration to those cities that have experienced shortages in past summers, as well as to those municipalities which are exceeding their safe yield. Municipalities may be ordered to increase their well capacities whenever shortages or marked reductions in pressures are found to exist because of insufficient capacities.

Orders of Necessity

Laws of the state of New Jersey grant the health department authority to issue Orders of Necessity to permit municipalities to exceed their bonded debt limits so that they may finance necessary improvements for the protection of public health. Not only can the department order a municipality with an inadequate water supply to correct this condition, but it can grant such a municipality an Order of Necessity which will authorize the fund-raising activities necessary to finance the required improvements.

Meter Reading and Commercial Department Operation

By Kenneth K. King

A paper presented on April 30, 1951, at the Annual Conference, Miami, by Kenneth K. King, Director of Public Works, Phoenix, Ariz.

IN managing utility operations it is often desirable to conduct an audit or critical examination of operations to ascertain whether they are being conducted efficiently and whether services are being performed in accordance with standards in other cities. Many of these standards of service and unit costs of operation are unfortunately not readily available for comparison and this important phase of management is therefore overlooked.

It was the purpose of this study to: [1] collect and tabulate information and cost data on meter reading and commercial operations of the water departments in cities of the United States having 1950 populations between 80,000 and 220,000; [2] draw comparisons among three groups of cities—northern cities, southern cities and cities having combined utility operations of water and electricity or water and gas; and [3] compare the 1950 data with similar information collected in 1940, to show trends in operations and changing costs.

Rising costs make it necessary to conduct all utility operations as efficiently as possible to maintain high standards of service within the limits of financial appropriations. A constant search for methods of cutting overhead and improving operations must consequently be undertaken. Many factors of efficiency and management are apparent in Tables 1–4.

Sources of Data and Procedure

A similar report (1), gave data for the year 1940, and the same techniques were employed in assembling and presenting the data for this 1950 report to enable direct comparison with the 1940 information.

When questionnaires were mailed, information was not available from the 1950 census providing complete coverage of all cities in the 80,000–220,000 population group. Questionnaires were therefore sent to 96 cities that were assumed to fall within the group, although large population increases raised some of the cities out of the selected class and undoubtedly placed other cities that were not polled within the class. Information was received from 71 cities, and 54 were found to fall within the limits of population selected for study. The 1940 report was based on data obtained from 47 cities for meter reading costs and 37 cities for commercial department expenses. Most of the cities included in 1940 are also studied in this investigation.

Variations in organization and management made it difficult for many cities to answer the questionnaire completely. Some information was therefore not supplied, resulting in blank spaces in the tables. There are probably also some errors in the tabulated figures because of incorrect interpretation of the information given, as it was sometimes indefinite.

TABLE 1—*Commercial*

	Pop. Incl. Suburbs	Active Services		Coml. Expense—$	Employees	Annual Cost—$	
		Total	Metered			Per Active Service	Per Person Served
Northern Cities							
1. Allentown, Pa.	110,000	26,520	2,155	38,556	7	1.45	0.350
2. Canton, Ohio	130,000	32,010	32,010	62,530	15	1.95	0.482
3. Des Moines, Iowa	194,523	47,860	47,655	134,234	26	2.81	0.690
4. Binghamton, N.Y.	81,132	14,340	14,340	31,910	11	2.23	0.393
5. Evansville, Ind.	150,000	34,000	34,000	34,000	—	1.00	0.227
6. Fall River, Mass.	125,000	14,200	14,050	—	—	—	—
7. Flint, Mich.	165,000	42,466	42,466	64,004	—	1.51	0.388
8. Grand Rapids, Mich.	180,000	45,077	44,582	—	—	—	—
9. Harrisburg, Pa.	150,000	24,744	24,682	—	—	—	—
10. Lansing, Mich.	109,300	22,932	22,932	39,101	10.5	1.71	0.367
11. Lowell, Mass.	132,779	15,000	15,000	—	—	—	—
12. Manchester, N.H.	85,000	14,300	14,000	25,300	—	1.78	0.297
13. New Bedford, Mass.	125,000	18,300	18,000	39,000	15	2.13	0.312
14. Newton, Mass.	81,376	—	21,383	—	—	—	—
15. Niagara Falls, N.Y.	110,000	19,000	19,000	—	—	—	—
16. Pawtucket, R.I.	130,000	22,511	22,189	—	—	—	—
17. Quincy, Mass.	83,093	18,296	18,162	—	—	—	—
18. Reading, Pa.	130,667	28,158	28,158	—	—	—	—
19. Rockford, Ill.	85,000	23,000	23,000	—	—	—	—
20. Saginaw, Mich.	150,000	23,088	23,088	21,500	8	0.93	0.143
21. Salt Lake City, Utah	204,800	47,688	45,688	69,866	—	1.47	0.341
22. Schenectady, N.Y.	102,452	20,197	1,039	87,519	—	4.33	0.853
23. Sioux City, Iowa	90,000	21,000	21,000	—	—	—	—
24. South Bend, Ind.	115,000	32,750	32,750	—	—	—	—
25. Spokane, Wash.	187,072	44,140	44,140	69,850	23	1.59	0.374
26. Springfield, Ohio	94,000	18,517	18,517	—	—	—	—
27. St. Joseph, Mo.	82,500	20,600	14,900	—	—	—	—
28. Trenton, N.J.	192,930	41,026	19,840	45,477	—	1.11	0.235
29. Troy, N.Y.	85,000	15,000	225	—	—	—	—
30. Utica, N.Y.	135,000	24,000	23,893	54,457	—	2.26	0.403
31. Worcester, Mass.	205,600	30,000	30,000	48,000	—	1.60	0.234
32. Yonkers, N.Y.	145,000	22,000	22,000	—	—	—	—
33. Youngstown, Ohio	185,000	39,715	39,643	—	—	—	—
TOTAL	4,332,224	862,435*	794,427	865,304*	115.5*	29.86*	6.089*
1950 Avg.	131,280	26,950	24,087	54,082	14.4	1.87	0.381
1940 Avg.	142,025	27,394	24,953	42,015	20	1.55	0.296
Southern Cities							
34. Baton Rouge, La.	150,000	31,000	31,000				
35. Berkeley, Calif.	112,125	29,000	29,000		12		
36. Charleston, S.C.	135,000	19,689	19,581				
37. Charlotte, N.C.	140,000	34,921	34,921	92,394	31		
38. Chattanooga, Tenn.	215,000	39,495	39,495	74,505	31	1.89	0.346
39. El Paso, Tex.	130,000	23,336	23,336	98,905		4.23	0.761
40. Little Rock, Ark.	111,151	27,966	27,826	64,024		2.29	0.576
41. Mobile, Ala.	150,000	30,481	30,389				
42. Montgomery, Ala.	130,000	23,000	20,856		29		
43. Pasadena, Calif.	127,860	35,849	35,849	78,682		2.19	0.616
44. Phoenix, Ariz.	180,000	40,142	36,513	128,186	35	3.17	0.705
45. Sacramento, Calif.	144,440	41,147	270	29,000	7	0.71	0.201
46. Savannah, Ga.	150,000	29,000	29,000				
47. Shreveport, La.	168,000	30,600	29,600				
48. Tampa, Fla.	175,000	40,707	40,707				
49. Tulsa, Okla.	212,900	51,251	51,251	149,992	55	2.92	0.703
TOTAL	2,431,476	527,584	479,594	715,688*	200*	17.40*	3.908*
1950 Avg.	151,967	32,974	29,975	89,461	28.6	2.49	0.558
1940 Avg.	152,762	29,591	29,195	49,069	27	1.66	0.321
Cities With Combined Water and Gas or Elec. Utils.							
50. Austin, Tex.	150,000	33,902	33,902				
51. Duluth, Minn.	110,000	22,255	22,255				
52. Fort Wayne, Ind.	180,000	36,831	36,825	122,498		3.33	0.680

Department Data

	Acctg. System	No. of Bills per Year	Cost per Bill—$	Deliv. Method	Delinquency Penalty		Discount for Promptness	Amt. Delinquent *per cent*
					Assessment	Rigid Shutoff		
1	Ledger	33,565	1.150	Letter-Flat Card-Meter	Yes—5%	No	Yes—25%	0.2
2	Combination	128,000	0.488	Card	—	Yes	Yes—10%	2
3	Ledger	193,081	0.695	Letter	No	No	No	11
4	Card	—	—	Letter & Card	Yes	Yes	No	None
5	Stub	136,000	0.250	Letter & Hand	No	No	No	5
6	Ledger	58,000	—	Letter	Yes—10%	No	No	2
7	Ledger	180,000	0.355	Card	Yes—10%	Yes	No	0.5
8	Ledger	176,206	—	Card	Yes—10%	Yes	No	5
9	Combination	120,000	—	Letter	Yes—2%	Yes	No	2
10	Ledger	93,378	0.418	Card	Yes—10%	Yes	Yes—1/11 of gross	6
11	Combination	60,000	—	Letter	No	No	Yes—5%	33.3
12	Card	58,000	0.437	Letter & Hand	Yes—20¢	No	No	—
13	Combination	33,000	1.182	Letter	Yes—50¢	Yes	No	0.07
14	Ledger	39,500	—	Letter	Yes—20¢	No	No	—
15	Card	76,000	—	Hand	Yes—10%	No	Yes—10%	5
16	Card	22,126	—	Letter	No	No	No	3.5
17	Combination	37,000	—	Letter	Yes	No	No	0.079
18	Card	117,450	—	Hand	Yes—5%	Yes	No	0.5
19	Card & Ledger	95,000	—	Card	Yes	No	Yes—5%	0.5
20	Combination	96,000	0.224	Card	Yes—10%	Yes	No	15
21	Stub	189,602	0.368	Card	No	Yes	No	3
22	Card	22,000	0.397	Letter	Yes—¾% per Month	No	No	1
23	Ledger	64,000	—	Letter	Yes	No	No	1
24	Ledger	133,200	—	Letter	Yes—10% to $3; 3% thereafter	No	No	1
25	Ledger	164,658	0.424	Letter	No	No	No	9
26	Combination	74,068	—	Letter	No	Yes	No	—
27	Stub	82,400	—	Card	No	No	No	0.97
28	Ledger & Card	124,000	0.366	Letter	Yes—Loss of 10% Discount	Yes	Yes—10%	None
29	Ledger	60,900	—	Letter	Yes—2%	Yes	No	8
30	Stub	85,000	0.640	Card	—	Yes	Yes—2%	1
31	Combination	60,000	0.800	Card & Hand	No	No	No	1
32	Ledger	22,000	—	Letter	Yes	No	No	20
33	Ledger	158,000	—	Card	No	Yes	Yes—10%	None
	55% Ledger	2,880,541*	8.194*	9% Hand	68% Yes	45% Yes	27% Yes	
	45% Stub			91% Mail	32% No	55% No	73% No	
		90,017	0.546					
	55% Ledger	103,936	0.405	14% Hand	61% No	65% No	67% No	
	45% Stub			86% Mail	39% Yes	35% Yes	33% Yes	
34	Stub	375,000		Card	No	Yes	Yes—10%	2.9
35	Combination	171,734		Letter	No	No	No	—
36	Combination	88,000		Card	Yes—$1.00	Yes	No	—
37	Card	385,212		Card	Yes—$1.00	Yes	No	5
38	Stub	172,875	0.431	Card	No	No	No	6
39	Card	280,032	0.353	Card	No	No	No	30
40	Stub	326,629	0.196	Card	Yes—10%	Yes	No	—
41	Ledger	360,000		Card	Yes—$1.00	Yes	No	10
42	Stub	275,000		Card	Yes—$.50	Yes	No	25
43	Stub	228,888	0.343	Letter	No	Yes	No	1
44	Ledger	495,000	0.257	Card & Hand	Yes—$1.00	No	No	15
45	Card	581,000	0.060	Card	No	No	No	.5
46	Stub	348,000		Card	No	Yes	No	—
47	Combination			Hand	No	No	No	5
48	Stub			Card	No	Yes	Yes—10%	3†
49	Ledger	561,273	0.267	Letter & Hand		Yes	Yes—5%	40
	28% Ledger	4,648,643*	1.897*	12.5% Hand	40% Yes	62½% Yes	19% Yes	
	72% Stub			87.5% Mail	60% No	37½% No	81% No	
		332,046	0.271					
	40% Ledger	293,416	0.167	35% Hand	20% No	20% No	80% No	
	60% Stub			65% Mail	80% Yes	80% Yes	20% Yes	
50	Stub	407,000		Hand	Yes—$1.00	Yes	No	.25
51	Stub	267,060		Letter	No	Yes	No	—
52	Stub	400,000	0.306	Letter	No	No	No	23

TABLE 1—

	Pop. Incl. Suburbs	Active Services		Coml. Expense—$	Employees	Annual Cost—$	
		Total	Metered			Per Active Service	Per Person Served
53. Glendale, Calif.	95,398	25,248	25,000	76,571	16	3.03	0.803
54. Kansas City, Kan.	160,000	31,576	31,576				
55. Lincoln, Neb.	110,000	24,985	24,985	62,399	31	2.50	0.567
TOTAL	805,398	174,797	174,543	261,468*	47*	8.86*	2.050*
1950 Avg.	134,233	29,133	29,090	87,156	23	2.95	0.683
1940 Avg.	145,483	31,573	29,783	48,410	35	1.62	0.332
TOTAL, ALL CITIES	7,569,098*	1,564,816*	1,448,564*	1,842,460*	362.5*	56.12*	12.047*
1950 Avg.	137,620	28,978	26,338	68,239	21.3	2.16	0.463
1940 Avg.	145,768	29,004	27,274	45,477	25	1.57	0.312

* Not all cities used·

TABLE 2—*Meter*

	Pop. Incl. Suburbs	Active Services		Reading Period*	No. of Readers	Readings per Year	
		Total	Metered			Total	Per Reader
Northern Cities							
1. Allentown, Pa.	110,000	26,520	2,155	M, Q	1	9,860	9,860
2. Binghamton, N.Y.	81,132	14,340	14,340	M, B, S, A	3	41,612	13,870
3. Canton, Ohio	130,000	32,010	32,010	M, Q	5	140,000	28,000
4. Des Moines, Iowa	194,523	47,860	47,655	M, Q	7	200,000	28,600
5. Evansville, Ind.	150,000	34,000	34,000	M, Q	10	136,000	13,600
6. Fall River, Mass.	125,000	14,200	14,050	M	10	56,000	5,600
7. Flint, Mich.	165,000	42,466	42,466	M, Q	5	180,000	36,000
8. Grand Rapids, Mich.	180,000	45,077	44,582	M, Q	9	168,000	18,640
9. Harrisburg, Pa.	150,000	24,744	24,682	M, Q	5	125,000	25,000
10. Lansing, Mich.	109,300	22,932	22,932	M, Q	3	93,918	31,310
11. Lowell, Mass.	132,779	15,000	15,000	M, Q	7	60,000	8,570
12. Manchester, N.H.	85,000	14,300	14,000	M, Q	4	58,000	14,500
13. New Bedford, Mass.	125,000	18,300	18,000	M	10	210,000	21,000
14. Newton, Mass.	81,376	—	21,383	Q	4	39,500	9,875
15. Niagara Falls, N.Y.	110,000	19,000	19,000	Q	5	76,000	15,200
16. Pawtucket, R.I.	130,000	22,511	22,189	Q	9	90,000	10,000
17. Quincy, Mass.	83,093	18,296	18,162	Q	5	—	—
18. Reading, Pa.	130,667	28,158	28,158	M, Q	6	128,784	21,460
19. Rockford, Ill.	85,000	23,000	23,000	Q	1.5	92,000	61,300
20. Saginaw, Mich.	150,000	23,088	23,088	M, Q	3	110,000	36,700
21. Salt Lake City, Utah	204,800	47,688	45,688	M, Q	5	189,602	37,920
22. Schenectady, N.Y.	102,452	20,197	1,039	M, S	1	2,918	2,918
23. Sioux City, Iowa	90,000	21,000	21,000	M, S	4	75,000	18,750
24. South Bend, Ind.	115,000	32,750	32,750	M, Q	7	133,200	19,000
25. Spokane, Wash.	187,072	44,140	44,140	M†	6.5	161,806	24,900
26. Springfield, Ohio	94,000	18,517	18,517	M, Q	4	74,000	13,500
27. St. Joseph, Mo.	82,500	20,600	14,900	M, Q	2	60,000	30,000
28. Trenton, N.J.	192,930	41,026	19,840	M, Q	13	80,000	6,150
29. Troy, N.Y.	85,000	15,000	225	M, Q	1	900	900
30. Utica, N.Y.	135,000	24,000	23,893	Q	5	85,000	17,000
31. Worcester, Mass.	205,600	30,000	30,000	B	9	190,000	21,100
32. Yonkers, N.Y.	145,000	22,000	22,000	S	10	44,000	4,400
33. Youngstown, Ohio	185,000	39,715	39,643	M, Q	10	168,000	16,800
TOTAL	4,332,224	862,435‡	794,427	M 7% M, Q 66% Q 20% M, S 7%	190	3,801,100‡	622,423‡
1950 Avg.	131,280	26,950	24,087		5.76	118,790	19,450
1940 Avg.	142,105	28,082	24,310	M 8%, Q 32% M, Q 52% M, 4M 4% B 4%	5.25	110,582	24,751

Continued

	Acctg. System	No. of Bills per Year	Cost per Bill—$	Deliv. Method	Delinquency Penalty		Discount for Promptness	Amt. Delinquent *per cent*
					Assessment	Rigid Shutoff		
53	Ledger	324,000	0.237	Letter & Hand	No	Yes	No	—
54	Card	378,912		Card	Yes—5%	Yes	No	7
55	Card	106,360	0.587	Letter & Hand	No	Yes	No	20
	17% Ledger	1,883,332	1.130*	33% Hand	33⅓% Yes	83% Yes	100% No	
	83% Stub			67% Mail	67% No	17% No		
		313,888	0.377					
	50% Ledger	288,600	0.168	44% Hand	44% No	50% No	100% No	
	50% Stub			56% Mail	56% Yes	50% Yes		
	43% Ledger	9,412,516*	1.194*	14% Hand	60% Yes	55% Yes	22% Yes	
	57% Stub			86% Mail	40% No	45% No	78% No†	
		181,010	0.475					
	50% Ledger	200,065	0.227	25% Hand	49% No	51% No	78% No	
	50% Stub			75% Mail	51% Yes	49% Yes	22% Yes	

† Thirty days, 17 per cent; older, 3 per cent.

Reading Data

	Annual Sal. Readers—$	Reader Cost—*dollars*		Proportion of Meters—*per cent*			Bearer of Repair Costs
		Annual per Service	Avg. per Reading	Customer Owned	In Basements	In Outside Boxes	
1	2,608	1.210	0.265	0.2	99.4	0.6	Dept.§
2	8,685	0.605	0.209	6	99	1	Dept. to 2"§
3	13,620	0.426	0.097	0	98	2	Dept.§
4	18,587	0.391	0.093	0	90	10	Dept.§
5	31,200	0.918	0.229	0.5	10	90	Dept.
6	25,000	1.780	0.447	60	100	0	Dept.
7	15,619	0.368	0.087	0.5	99.5	0.5	Dept.
8	20,717	0.464	0.123	0	90	10	Dept.§
9	13,651	0.552	0.109	—	100	0	Dept. to 1"§
10	9,881	0.432	0.105	0	—	—	Dept.§
11	19,017	1.268	0.317	0	99	1	Dept. to 1"§
12	11,648	0.832	0.201	0	100	0	Dept.§
13	22,500	1.250	0.107	8	92	8	Both‖
14	12,000	0.561	0.304	0	98	2	Dept.§
15	15,500	0.815	0.204	100	98	2	Dept. to 1"§
16	18,720	0.843	0.208	34	99	1	Dept.§
17	14,100	0.777	—	0	94	6	Dept.
18	16,136	0.573	0.125	0	90	10	Dept.
19	—	—	—	100	95	5	Dept. to 1"§
20	8,750	0.379	0.080	0	94	6	Dept.§
21	13,800	0.302	0.073	2	8	92	Dept.§
22	3,050	2.930	1.045	5.1	50	25	Dept. to 1¼"§
23	10,035	0.478	0.134	1	95	5	Dept.§
24	18,480	0.563	0.137	0	95	5	Dept.§
25	21,420	0.486	0.133	100	80	20	Dept.§
26	11,760	0.635	0.159	0	87	13	Dept.§
27	5,200	0.349	0.087	0	25	75	Dept.
28	21,930	1.104	0.219	0	70	30	Dept.§
29	2,200	9.760¶	2.442¶	25	60	40	—
30	15,400	0.643	0.181	0	95	5	Dept. to 1"§
31	26,832	0.895	0.141	100	99	1	Dept.§
32	27,000	1.227	0.613	100	90	10	Dept. to 1"
33	33,000	0.833	0.197	100	100	0	Dept.§
	508,046‡	24.889‡	6.429‡				
	15,876	.801	0.214	19.9	79	21	97% Dept.
	8,392	.345	.076	32	82	18	88% Dept.

TABLE 2—

	Pop. Incl. Suburbs	Active Services		Reading Period*	No. of Readers	Readings per Year	
		Total	Metered			Total	Per Reader
Southern Cities							
34. Baton Rouge, La.	150,000	31,000	31,000	M	4	375,000	93,770
35. Berkeley, Calif.	112,125	29,000	29,000	B	—	—	—
36. Charleston, S.C.	135,000	19,689	19,581	M, Q	3	89,700	29,900
37. Charlotte, N.C.	140,000	34,921	34,921	M	10	419,052	41,905
38. Chattanooga, Tenn.	215,000	39,495	39,495	M, Q	4	171,710	42,927
39. El Paso, Tex.	130,000	23,336	23,336	M	4	280,032	70,008
40. Little Rock, Ark.	111,151	27,966	27,826	M	3	343,272	114,424
41. Mobile, Ala.	150,000	30,481	30,389	M	12	360,000	30,000
42. Montgomery, Ala.	130,000	23,000	20,856	M	5	250,272	50,054
43. Pasadena, Calif.	127,860	35,849	35,849	M, B	2.5	223,740	89,300
44. Phoenix, Ariz.	180,000	40,142	36,513	M	9	456,000	50,667
45. Sacramento, Calif.	144,440	41,147	270	M	1	3,240	3,240
46. Savannah, Ga.	150,000	29,000	29,000	M	14	348,000	24,900
47. Shreveport, La.	168,000	30,600	29,600	M	5	367,200	73,440
48. Tampa, Fla.	175,000	40,707	40,707	M	7	488,484	69,783
49. Tulsa, Okla.	212,900	51,251	51,251	M	10	561,273	56,127
TOTAL	2,431,476	527,584	479,594	M 80% M, Q 13% M, B 7%	93.5‡	4,736,975‡	840,445‡
1950 Avg.	151,967	32,974	29,975		6.23	315,798	56,030
1940 Avg.	145,306.84	28,583	27,415	M 85% M, Q 15%	4.75	287,226	68,444
Cities With Combined Water and Gas or Elec. Utils.							
50. Austin, Tex.	150,000	33,902	33,902	M	4	407,000	101,750
51. Duluth, Minn.	110,000	22,255	22,255	M	14	593,652	42,300
52. Fort Wayne, Ind.	180,000	36,831	36,825	M	24	442,000	18,400
53. Glendale, Calif.	95,398	25,248	25,000	M, B	6	—	—
54. Kansas City, Kan.	160,000	31,576	31,576	M	—	378,912	—
55. Lincoln, Neb.	110,000	24,985	24,985	M, Q	3.6	110,750	30,700
TOTAL	805,398	174,797	174,543	M 67% M, Q 17% M, B 16%	51.6‡	1,932,314‡	193,150‡
1950 Avg.	134,233	29,133	29,090		10.32	386,463	48,287
1940 Avg.	145,484	31,573	29,783	Q 11%	6.5	263,240	40,958
TOTAL, ALL CITIES	7,569,098‡	1,564,816‡	1,448,564‡	M 36% M, Q 44% Q 12% M, S 4% M, B 4%	335.1‡	10,470,389‡	1,656,018‡
1950 Avg., all cities	137,620	28,978	26,338		6.32	201,353	32,471
1940 Avg.	143,638	28,878	26,217	M 41% Q 19% M, Q 36% M, 4M 2% B 2%	5.3	188,674	39,940

* Denoted by M—monthly, B—bimonthly, Q—quarterly, S—semiannually, A—annually.
† Also every four months.
‡ Not all cities included.

Commercial Department Data

The average commercial department expenses of southern cities and cities with combined utilities are considerably more than those of northern cities. This condition is contrary to the findings of the 1940 survey, in which the three groups varied little. The average for all cities is 50 per cent higher than in 1940. The same relationships were found for costs per active service, which show a 37 per cent increase, and for costs per person served, which show a 49 per cent increase.

The average expense per bill varies greatly. The billing periods in the North are such that less than one-third as many bills are sent as in the other two groups. This situation accounts for the lower average commercial department expenses in the North. It does not follow, however, that average

Continued

	Annual Sal. Readers—$	Reader Cost—*dollars*		Proportion of Meters—*per cent*			Bearer of Repair Costs
		Annual per Service	Avg. per Reading	Customer Owned	In Basements	In Outside Boxes	
34	—	—	—	0	0	100	Dept.
35	—	—	—	0	—	—	Dept.
36	—	—	—	0	0	100	Dept.§
37	23,316	0.668	0.056	100	0	100	Dept.§
38	13,079	0.331	0.076	0	0	100	Dept.
39	—	—	—	0	1	99	Dept.§
40	6,000	0.216	0.018	0	.25	99.75	Dept.
41	28,308	0.930	0.079	0	0	100	Dept.
42	9,900 est.	0.475	0.039	—	1	99	Dept.
43	8,310	0.231	0.037	0	0	100	Dept.§
44	27,000	0.739	0.059	0	.5	97.5	Dept.§
45	3,252	12.020¶	1.008¶	2	—	—	Dept.§
46	17,736	0.612	0.051	—	0	100	Dept. to 1"
47	13,020	0.439	0.035	0	0	100	Dept.§
48	16,968	0.417	0.035	0	0	100	Dept.§
49	24,740	0.483	0.042	0	.1	99.9	Dept.
	191,629‡	5.541‡	0.527‡				
	15,969	0.504	0.048	7.3%	0.2%	99.8%	100% Dept.
	7,256	.265	.025	25	1	99	90% Dept.
50	10,320	0.305	0.025	0	0	100	Dept.
51	37,800 est.	1.700	0.064	0	100	0	Dept.§
52	37,000	1.006	0.084	—	95	5	Dept.§
53	19,224	0.769	—	0	0	100	Dept.
54	—	—	—	100	72	28	Dept. to ¾"§
55	8,480	0.339	0.077	100	90–95	5–10	Consumer
	112,824‡	4.119‡	0.250‡				
	22,565	0.824	0.063	32.4%	59%	41%	83% Dept. 17% Consumer
	9,912	.332	.038	37.5	58%	42%	85% Dept.
	812,499‡	34,069‡	7.206‡				
	16,582	0.723	0.160	17.2%	51%	49%	97% Dept. 3% Consumer
	8,369	.319	.044	30.5	54.5%	45.5%	88% Dept. 12% Consumer

§ Costs borne by department except if meters are damaged through user's fault.
‡ Customer if customer-owned; department§ if city-owned.
¶ Not included in totals.

costs per bill are equalized, as the average cost in northern cities is twice that of southern cities and 45 per cent greater than in the cities having combined utilities. Practically the same relationships existed in 1940, although the average cost per bill for all cities has risen 110 per cent since then.

The trend over the ten-year period indicates that mail delivery is more widely used than hand delivery of bills. In 1940, 25 per cent of the deliveries were made by hand and 75 per cent of them by mail, whereas in 1950, only 14 per cent of the deliveries were made by hand.

Use of stub and ledger systems was equal in 1940, but in 1950 the use of stub systems was more popular, with 57 per cent of the systems using them.

As in 1940, the proportion of delinquency did not seem to be correlated

with the severity of regulations—that is, whether a rigid shutoff rule existed or a penalty or discount was applied.

Meter Reading Data

The proportion of active services which are metered has changed very little since 1940. In 1940 it was found that 93 per cent of the active services were metered, whereas in 1950 only 91 per cent were metered. A larger sample was used in the latter survey.

The average cost per meter reading is perhaps the best single index among the tabulations. The current average is 16¢ compared with 4.4¢ in 1940. The northern cities were 34 per cent higher, the southern cities 70 per cent lower, and the cities of combined utilities 60 per cent lower than the average. The average cost per meter reading is considerably less in the South than in the North. This situation is to be expected because of the greater accessibility of meters in warm climates, where meters are in outside boxes.

As in 1940 salaries have no apparent relation to locality, although they are slightly higher in the northern cities. The average salary of meter readers is $218 per month compared with $130 per month in 1940.

The tabulations take no account of the many collateral duties of meter readers, such as inspecting, collecting and turning services off and on. A wide variation in the number of readings per year per reader is also shown. The readers in several cities make more than 100,000 readings per year, whereas others make 5,000–10,000 per year. It is obvious that the large-volume readers do nothing but read meters, whereas the others perform other duties. Some account probably should have been taken of the population density, as the statistics on meter readings indicate higher costs in cities with lower densities.

In 1940 meters were 30.5 per cent customer-owned. This proportion of customer-owner meters has been reduced considerably, to 17.2 per cent in 1950. The number of meters in basements has declined slightly, from 54.4 to 51 per cent since 1940. In 1940, 88 per cent of the departments bore the cost of meter repairs, whereas in 1950 this figure was 97 per cent. Most of the departments, however, did charge the customer when damage was not due to normal use.

Acknowledgment

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Reference

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Drawing Water From a Dune Area

By Pieter C. Lindenbergh

A contribution to the Journal by Pieter C. Lindenbergh, Director of Water Works, Leyden, Netherlands.

SOURCES of the Leyden Dunewater Co. are situated in the ridge of dunes that stretches along the coast of the North Sea in the Netherlands.

Space does not permit a thorough discussion of the geologic background of the dunes, but mention of the more important phenomena concerning the genesis of these dunes is necessary—especially for the immediate area from which the water is being taken.

Geologic Background

Long ago a barrier of dune sand existed a little to the east of the present sand dunes which protect the country from inundation. Large stretches of the old ridge can still be found at several places. This barrier was originally flanked on both sides by salt water which was gradually displaced, on the land side, by fresh water from the rivers, mainly the Rhine. When the icecap which covered northern Europe approximately to the center of the Netherlands during the glacial age started to melt, the Rhine drained great quantities of this melted water and broke through the barrier. The area from which Leyden Dunewater Co. takes its water is the spot where the prehistoric breakthrough occurred. When the quantities of water to be drained off decreased, the mouth of the Rhine gradually filled up again. First the coarse sand settled down, then sand with ooze, and ultimately everything became covered with a layer of river clay. This type of clay can also be found along the banks of the river further upstream.

Approximately 5,000 years ago, because of a rising of sea level, another breakthrough took place, forming the Straits of Dover, and large quantities of sand started to move along the coast. Sand dunes were again formed in the old mouth of the Rhine. These new dunes, are also in the area from wh'ch the water is obtained for the Leyden Dunewater Co. They are thus divided horizontally into two parts by an almost solid clay layer situated approximately 1–2 m.* below average sea level.

Hydrologic Background

When the barrier rose above the salt water, rain started to fall on it. About 60 per cent of that fresh water penetrated through the sand until it reached the phreatic level—the salt water. Since fresh water is lighter than salt water, it floated on the salt water, and the sand prevented the mixing of the two. This action continued for centuries and a large supply of fresh water finally accumulated in the sand dunes. The fresh water penetrated until it reached a depth of $40h$ † under the level of the salt water.

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* One meter equals 3.28 ft.

† The height of the fresh water level above the original salt water level in the center of the dunes is represented as h. This ratio is in consequence of the difference between the specific weight of fresh and salt water.

The hydrological situation is, however, being influenced by the clay layer. This fact has great bearing upon the obtaining of the water. The water underneath the clay layer is called "deep water" while that from above is known as "upper water." Only under exceptional conditions can water be drawn from the deep water for domestic use. This became apparent even before local geological situation had been investigated. Large quantities of deep water were withdrawn regularly in imitation of other water procurement practices, but most of the wells became oversalted. It was mainly because of this situation that the Netherlands Government Institute for Water Supply was requested to investigate. Orders were therefore given that the water supply for the Leyden Dunewater Co. had to be drawn from the upper water, and that deep water could be used only in emergencies.

Irrigation of the Area

The upper water comes directly from the rain with approximately 60 per cent of the rainfall benefiting it. The average rainfall and the available sand dune area are known exactly. It is therefore possible to calculate the maximum capacity of the sources from which the water is to be taken. As an extension of the dune area was not possible and the amount of water which would be available per year was not sufficient for the area to be supplied, the only conclusion which could be drawn was that the present sources of the company were unable to supply sufficient water for the area controlled by it for an unlimited time. Another source of supply was therefore necessary. Contrary to expectation, the solution of that problem was very difficult and expensive in the Netherlands, a country which is so rich in water.

The water in the canals and lakes of northern and southern Holland is too brackish and, generally speaking, too polluted to be used for drinking. The higher grounds to the east and the rivers are therefore the obvious sources. This solution, however, involves, apart from very high expense, several other important objections which can be left out of the present discussions.

The company management looked in many directions for an economic solution to its acute water shortage. The investigations disclosed that, in the winter, considerable quantities of water of an excellent quality flowed down to the foot of the sand dunes and from the sandy grounds, into the polder. It appeared possible to trap a large part of this water and to pump it back into the dunes.

Legal Problems

In addition to the technical difficulties, a legal problem arose. The owners of the lands upon which flower bulbs are grown contended that they were being injured by the removal of the water from the ground in which their plants grow.

The owners of the land upon which the dunes were located also claimed damages as the contemplated project threatened the continuance of one of their practices. This practice had been removing the layer of sand, selling it and using the new, uncovered surface for the further growing of bulbs. The Leyden Dunewater Co. countered these claims with the contention that their sources of water were being impaired by the sand removal.

Negotiated Agreement

The situation was finally resolved to the satisfaction of all parties by negotiation of an agreement which provided that:

1. An area with a total surface of approximately 50 ha.,* consisting mainly of sand dune ground and partly of fields previously used for agriculture, will be leveled to approximately 4 m. above average sea level, without opposition from the Leyden Dunewater Co.

2. This area will be irrigated with water from the polder to a level of 3.60 m. above average sea level.

3. For the convenience of the Leyden Dunewater Co., as much water will be pumped into its sand dunes as is required to compensate it completely for the loss of water by the leveling of the ground.

Irrigation Plan

The company has taken this opportunity to set up an irrigation plan for its dunes on a much more elaborate scale than was required to meet the terms of the agreement. These irrigation works are shown in Fig. 1.

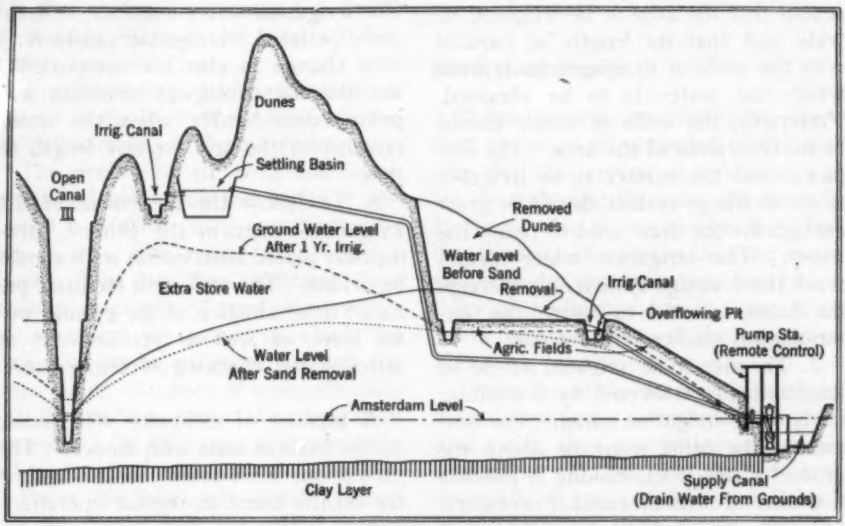


Fig. 1. Profile of Dunes and Agricultural Land

The water levels before and after excavation of the dune area are indicated. The canals and reclaimed agricultural lands are also shown. An additional storage of 656,400 cu.m. of water was achieved in the area. The Amsterdam water level is taken as the average sea level.

When drawing up its plans, the company took into account the possibility of carrying out a series of observations on the irrigation of sand dunes. It was thought that they might lead to more efficient irrigation practices.

Scientific tests and observations were carried out to supply data for the cal-

* One hectare equals 2.47 acres.

culations that were to be made. After the irrigation was begun, many observations were also made to provide a continuous check on the quality of the irrigation water as it passed through the dune sand. From the tests and observations, the following principles were adopted for guidance in irrigation practice:

1. To have sufficient storage accommodation for the water, it is essential that the area to be irrigated be wide and that its length be parallel with the wells or drainage canals from which the water is to be obtained. Preferably, the wells or canals should be on both sides of the area. The distance from the surface to be irrigated to the drainage system should be great enough for the dune sand to retain the water. The irrigation water should reach the drainage system only through the dunes, in order to control the bacteriological quality of the water.

2. The area to be irrigated should be longitudinally traversed by a shallow, fairly wide irrigation canal. The bottom of the canal must be above the ground water level, making it possible to drain and clean the canal if necessary.

3. The surface of the irrigation canal should be large enough to provide at least 2½ sq.m. of infiltration area for each cubic meter of water produced daily, giving an infiltration rate of at least 0.4 cu.m.* per sq.m. per day.

4. The water level in the canal must be temporarily increased to a level that will flood the overgrown little dune valleys entirely. This is necessary because if ample supplies of good irrigation water are available, a large quantity should be brought into the dunes in a short time.

5. It is desirable to have a small settling basin in which the water can be held after it has been pumped up and before being run into the irrigation canals. The water should not, however, be retained there fore more than a day or so to prevent growth of algae.

6. It is advisable to have several irrigation canals so that, if necessary, operation of one or more canals can be suspended for cleaning or other reasons.

7. Chemical control of the water to be pumped into the dunes is essential. The irrigation water must not be seriously polluted. Irrigation causes very little change in chemical composition, but the bacteriological condition improves considerably when the water remains in the soil for any length of time.

8. To follow the movement of the irrigation water in the ground, strategically placed observation wells should be drilled. The wells will facilitate periodic determination of the ground water level, as well as procurement of samples and checking of temperature.

A number of estimates were made on the basis of tests with models. The predictions were later checked against the results found in regular operations and were found to have been quite accurate.

In accordance with the forecasts derived from the model tests, the results of other irrigation projects and the directions mentioned above, plans for the irrigation of the area from which the water is being obtained were adapted to the available ground and implemented as described below.

Irrigation System Description

The drainage water from the sand dunes is being collected in the *Grote Wetering* (Big Watercourse) which has been deepened and, where necessary, widened. At a cross canal run-

*One cubic meter equals 264.17 gal.

ning in the direction of the dunes, a small pumping station has been built, and two vertical, electric-motor-driven pumps have been installed in it. They are controlled from the water tower, 5 km. distant.

The pump for the irrigation of the bulb grounds has a capacity of 700 cu.m. per hour and discharge head of 4 m. The pump for the irrigation of the area from which the water is obtained for the Leyden Dunewater Co. has a capacity of 340 cu.m. per hour and discharge head of 12 m.

A telemetering device transmits a record of the level of the water in the irrigation canals to the water tower.

The pipeline for the irrigation of the grounds from which the water is obtained is 1,600 m. long and discharges into a lake that serves as a settling basin. This lake has purposely been created in a natural sand dune valley to determine the extent to which the irrigation water will seep through the dune sand. An area of approximately 100 ha. has been prepared as irrigation grounds. Of this area approximately 10 ha. can be inundated.

From the lake, two canal systems can be fed at will by valved intake pipes. According to previous calculations, approximately 1,000,000 cu.m. of water can be brought and stored in the irrigation grounds above the ground water level of normal rainfall. The distance from the irrigation canals to the drainage system (140 m.) is such that it takes the irrigation water at least 60 days to reach the drainage system. Care has been taken, on the other hand, to see that the required amount of irrigation water is supplied to the bulb grounds.

The length and width of the irrigation canals have been fixed so that, when the system is completely filled, the rate of filtration (0.40 m. per day) is just great enough to balance the supply.

The valleys in the sand dunes, situated along the irrigation canals, may be considered as supplemental storage which will be useful if the dune sand is almost completely saturated with irrigation water and more water is still available. The additional storage capacity should hold approximately 100,000 cu.m. of water.

Results of Study

It has become apparent, after more than ten years of operation of the system, that the amount of irrigation water depends directly upon the rainfall. It should also be mentioned, however, that the stock of water in the sand dunes provided by the irrigation has had a favorable influence for at least three years on the capacity of the sources of the water supply.

Operation of the deep wells has been almost completely discontinued for several years, thus preventing salt water intrusion. During periods of long droughts it was possible to fall back temporarily on deep water, and the quality of the water thus obtained for all practical purposes did not vary in quality from the normal dune water.

Many observations have been made on water levels and quality. As already stated above, the calculated water level and the height observed in the test model, as well as the time the water remained in the sand, agree with the results obtained in practice. From these facts the following conclusions were drawn.

1. From the sources of a dune water supply, not more than 400 mm. per year of effective rainfall can be withdrawn.

2. This amount can be obtained only by using very efficiently built, and generally very expensive, works.

3. To control as large an area of sand dunes as possible, the shallow wells used by the Leyden Dunewater Co. provide the least expensive method of tapping the area under control. It would, in fact, be almost impossible to achieve this withdrawal with any other drainage system. This condition applies particularly to a sand dune area with an almost impenetrable layer of clay only slightly below the ground surface.

4. The sources from which the company obtains its water, because of the application of these wells, have been extended to approximately 800 ha. The capacity to supply water has thereby been increased to 3,200,000 cu.m. of upper water per year.

5. By intermittent irrigation with suitable water, the production capacity of the sources of dune water can be at least tripled.

6. The irrigation water, which during the winter and the spring is being pumped into the dunes in large quantities, can be stored in the dune sand and gradually released in proper quantities during the remainder of the year. This process can be regulated by adjusting the water levels in the drainage system. Long periods of droughts can be effectively overcome in this way.

7. To be able to use the water-accumulating capacity of the dune sand fully, 100 ha. of dune area should be available for every 1,500,000 cu.m. of water that is pumped into it per year. This practice will yield approximately 1,200,000 cu.m. per year.

8. It is essential that the grounds which are to be irrigated be provided with an adequate drainage system. Sand dune areas in which there are uninterrupted, almost impenetrable layers at a slight depth, are eminently suitable for irrigation.

9. The irrigation system applied at present to a part of the dune area of the Leyden Dunewater Co. increases the capacity of the sources by 1,000,000 cu.m. of water annually.

The proposed irrigation of *de Pan* (the Glen) by the construction of an irrigation canal will increase the capacity by another 1,000,000 cu.m. annually, on condition that an equal amount of water will be available for irrigation purposes. In this manner a very important reserve of water can be built up in the dunes during wet years. The total capacity of the sources for the supply of water would then be 4,500,000–5,000,000 cu.m. of water each year, exclusive of the deep water reserve. If even greater need for water should arise, it would be possible to extend the irrigation. The additional water, however, would have to be brought from elsewhere.

10. If the whole dune area at the old mouth of the Rhine River could be irrigated with suitable water, the capacity of the sources could be increased to at least 9,000,000 cu.m. of water yearly.

11. Irrigation water for dune areas must meet very high quality specifications.

12. The chemical composition of the irrigation water, for all practical purposes, does not change during passage through the dune sand. Color and taste as well as temperature are favorably influenced if the course through the sand is fairly long.

13. Irrigation is not necessary to improve the quality of drinking and industrial water.

14. The irrigation of the dunes is of great importance to the growth of plant and animal life in the dunes, and also to bulb growing and other agriculture at the foot of the dunes. The opposing interests of agriculture and bulb growing on the one hand, the provision of dune water on the other, become reconciled when irrigation is adopted. Great inconvenience and loss can thus be avoided for both parties. incidentally, to raise the pressure in the dunes to a more desirable level. This action is shown in Fig. 2.

Adequacy

The state of purification techniques is far enough advanced to supply water that meets all reasonable demands without irrigation, as long as sufficient useful raw water is available. When the dunes are being irrigated the

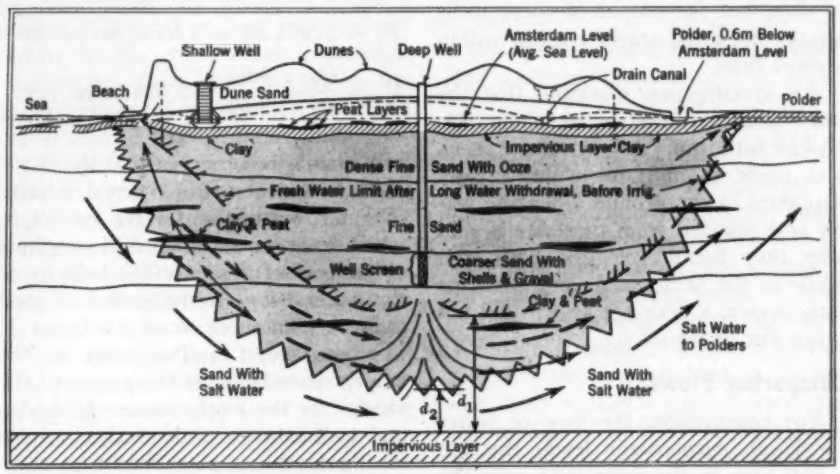


Fig. 2. Dune Area Soil Characteristics

The upsweeping arrows at the bottom of the diagram indicate the seepage of salt water into the well that resulted from overuse of the well. The polder level is 2 ft. below the Amsterdam level (sea level).

15. Continuous tapping of the deep wells, and the resultant removal of fresh water, caused a zone of decreased pressure into which salt water seeped from below and from there into the polders. It was found that by temporarily suspending the operation of each well for a short time, the new supply of fresh water that filtered in through the coarse sand of the surrounding area created sufficient pressure to hold back the salt water and, temporary storage of irrigation water becomes of paramount importance. If during two or three months of a particular year a sufficient amount of good irrigation water is being pumped into, and properly spread over, the dunes of a water supply area, it can be assumed that for such a year a regular water supply, as outlined in items 5 and 6, is guaranteed. The improvement of the quality of the water is then an additional factor.

New Well Construction

The development of the upper water is fairly expensive because the construction of wells created difficulties. It was possible to obtain the upper water with horizontal collectors, but this method also presented difficulties, as construction of works of sufficient capacity would be very expensive. Varied attempts have been made to construct ordinary wells above the layer of clay, but the output of these wells always declined, nearly ceasing within a short time.

An investigation disclosed that the sand near the obstructed wells was choked with iron. A very careful check was made to find out what actually happened in the ground when the water was pumped from those wells, and why they became clogged with iron while in the same sand, and with the same water, a drainage system did not cause similar troubles.

Comparing Flows

For comparison, the flow of water (V_b), at Amsterdam level, through a unit area in the dune sand near the gravel filter around the well and through a drainage system (V_d) may be calculated. For the well:

$$V_b = \frac{Q_b}{F_b}$$

The unit production of the well (Q_b) is 3 cu.m. per hour. The surface of the gravel filter, which almost reaches the clay layer (at the point 1.80 m. below Amsterdam level) is equal to $2\pi rh$; $r = 0.25$ m. and $h = 1.80$ m.

$$F_b = 2\pi 0.25 \times 1.80 = 2.83 \text{ sq.m.}$$

$$V_b = \frac{Q_b}{F_b} = \frac{3}{2.83} = 1.06 \text{ cu.m. per sq.m. per hour.}$$

For the drainage system,

$$V_d = \frac{Q_d}{F_d}.$$

The water production in practice in the drainage system is 1.2 cu.m. per full day per sq.m. For an hour,

$$Q_d = \frac{1.2}{24} = 0.05 \text{ cu.m.}$$

$$F_d = 2 \times 1.80 = 3.60 \text{ sq.m. per m.}$$

$$V_d = \frac{Q_d}{F_d} = \frac{0.05}{3.60} = 0.014 \text{ cu.m. per sq.m. per hour.}$$

It should be observed that the factor V is the extent not of the real velocity of water, but of that for the surface F, which has been assumed as if no grains of sand were present. The velocity of the water between the grains of sand is more than three times the factor V that was found, and depends on the empty space between the grains of the sand. As the empty spaces in drains and well sands are identical, the ratio of the V values is sufficient to compare the velocities. The ratio is:

$$V_b : V_d = 1.06 : 0.014.$$

The obvious difference is that the greater velocity of the water in the sand near a well causes it to carry the very small sand grains, and the sucking action also tends to carry air with it.

The open air can enter the gravel filter easily through the perforated portion of the well casing, which is above the water, and therefore enter the surrounding dune sand.

The entrained air coagulates the iron that is arrested between the grains and also in the gravel filter or the well.

The iron that remains behind in the dune sand and the gravel filter fills up the empty spaces and thereby further increases the velocity. In this way, the process is accelerated and gradually chokes the well. Regular cleaning is not a satisfactory remedy for this condition.

Reduction of Velocity

By excavating such a choked well, it appeared that the dune sand within a radius of about 1 m. had been colored brown by the iron. When a drainage system was used, the choking in the surroundings of the gravel filter was never noticed. It can therefore be concluded that the velocity in the dune sand near the gravel filters of the shallow wells has been too great. The inlet surface (F_b) has to be increased to reduce the inlet velocity. Increasing the length of the filters is not the solution as the clay layer in the area is too high.

For the purpose of increasing F_b, it was considered first to execute a series of borings to the clay layer so that the successive gravel filters would run into each other. A complete drainage system would thereby be created from which water could be drawn at several points. This solution is indeed feasible but is objectionable because:

1. The method is expensive.
2. The amounts of water to be drawn locally are very small and it would require an expensive installation, consisting of many small pumps with different central suction points, and would require digging to a level lower than 10 m. above Amsterdam level.
3. Against such a connected long body of coarse material in the dune sand the same objection which is raised to a drainage system prevails: a great risk of pollution that would necessitate prohibiting the public from entering the area.
4. When differences exist among the water levels in the area under consideration, the water runs quite easily through the coarse sand to the places with the lowest levels, flowing easily from them to the sea and elsewhere. The saving of water in the winter for summer use is therefore attended by more loss of water. In the area mentioned, differences of water levels are 4–5 m.

For these reasons, the series of borings was not executed.

Alternatives

Consideration was given to setting ordinary wells in circular groups. If they were so arranged, a central pumping installation could be placed at the center of each circle. Calculation of the diameter of each series of wells brought up the question of whether it would be possible to devise a serviceable construction, provided on the outside with a useful gravel filter, and also capable of accommodating a pumping installation. The problem was thus reduced to a mere technical matter.

The problem, then, is how large should V_b be? During filter tests, it appeared that a velocity of V_b equal to 0.50 m. per hour can be applied without any difficulty, and neither air nor sand would be carried along. Carefully constructed filter layers of river sand and gravel should be applied.

Normal rates of filtration of V_b equaling 10–20 cm. per hour never caused any difficulties. A normal filtration rate of V_p equal to 15 cm. per hour was consequently accepted for safety's sake when calculating the new construction of shallow wells. This rate can be increased considerably without any difficulty when necessary. To

reach this rate at a Q of 3 cu.m. per hour, an outside surface of the gravel filter under water of:

$$F_p = \frac{Q}{V_p} = \frac{3}{0.15} = 20 \text{ sq.m.}$$

is required. If the height of the gravel filters under water is h, the circumference should be $\frac{20}{h}$ m. The radius (r) of the gravel filter will, assuming that the gravel filter is circular, be:

$$r_p = \frac{20}{h} : 2\pi.$$

If h is equal to 1.80 m., it will be:

$$r_p = \frac{20}{1.8 \times 2\pi} = 1.78 \text{ m.}$$

Design of Well

An attempt had to be made to construct a well which could, by simple means, be sunk as far as the clay layer, together with a gravel filter having a diameter of 3.60 m. The construction had to be such that the open air could not penetrate easily into the gravel filter material, while iron parts had to be used as rarely as possible under water. A well of this type was successfully constructed.

It is obvious that a well with a diameter of 3.60 m. can hardly be constructed in the ordinary way, and very large and heavy equipment would be required. To sink a tube of 3.60 m. in diameter to a depth of 10 to 12 m., and to pull it up later on, is extremely difficult. Another difficulty, the installation of a heavy well casing and much gravel filter material, also arises.

The design created to meet all these difficulties was the setting of a short ring with a flange, called a "bottom piece," at the bottom of the concrete shaft. This assembly can be seen in Fig. 3. The gravel filter, consisting of gravel and river sand which were kept together during the sinking by galvanized wire gauze, rests on the bottom piece. The wire gauze was fastened to a strong wood frame. Immediately above the bottom piece flange are the inlet holes for the water.

The remaining construction of the well consists of concrete rings of 2-m.

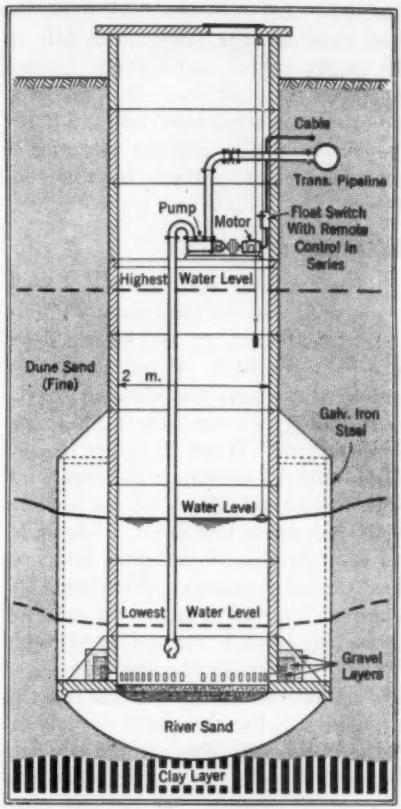


Fig. 3. Shallow Well

This well is used to obtain water from sources located near the surface in fine sand. The float switch is set in series and controlled remotely.

id. prepared before hand. Six parallel reinforcing rods protrude on one side. On the other side, a space remains in the concrete through which the reinforcing rods of the following ring can be fastened to the hook of the parallel reinforcement, left free in the space mentioned above. After fixing the rings, fastening the rods and then filling the spaces, a very strong well shaft exists. Strength is of the essence because the whole well starts to move repeatedly during the sinking process, and at times great force has to be applied at the top of the shaft to maintain the vertical position of the well.

The concrete bottom pieces must be made in series, in advance, and their construction must be very sturdy because when the structure is brought into the ground, the full weight of the well, including the gravel filters, will rest on the outer border.

Sinking a Well

The first step in sinking a well is the placing of a bottom piece horizontally on the sand at the exact proposed well site. Two or three rings are then placed on the bottom piece and fastened together to it. The gravel filters can then be brought in position. A small crane with a 300-l. grab next removes the dune sand from the bottom of the well through the shaft. The flow of sand into the excavation undermines the outer border, causing the well to sink. After excavating for a few hours, the first part of the well with rings and gravel filters will have almost completely disappeared into the sand. A few rings are again built up to a height that enables the grab to go in and out. Excavation then starts once more. This procedure continues until the clay layer or a satisfactory depth has been reached. After reaching the proper depth, the space underneath the well and the horizontal border are also filled up, as quickly as possible, with river sand and gravel, which serve as transition layers. The well is then ready. One well per week can be completed under normal conditions. The installation of a pump is the only remaining step before drawing water.

Test Well

One test well was installed to give the necessary experience and at the same time to suggest possible alterations in the construction and working methods. A forced pumping of that well at the rate of 9–12 cu.m. per hour was maintained for several months without experiencing any difficulty, although the water level in the surrounding area dropped as was expected.

A pump with a capacity of 4–5 cu.m. per hour was subsequently placed in the test well. It has worked continually for several years without reducing the production of water. No clogging took place in the gravel filters. It became apparent that the drawdown was slightly reduced with the same quantity of water pumped, indicating an increase in the water-producing capacity. At the bottom of the well, some iron deposit was formed, but it was removed very simply by a diaphragm pump.

Practicability Established

When the practicability of this method of well construction was established, 22 of the wells were placed in one of the canals. The water they produced was conducted to the adjacent canals by a siphon pipeline. One small, automatically revolving 1-hp. vacuum pump keeps the siphon free from air and well gas. The line lies on the bottom of that canal approximately 3.80

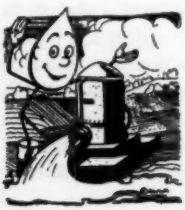
m. above Amsterdam level. The use of these wells made it possible to obtain water economically without digging a deep canal and, consequently, without damaging the natural beauty of the sand dunes.

In an open canal or drainage system, the water will remain horizontal. The water from higher dune water levels will flow to places with the lowest water levels, where the resistance to leakage is least. If wells are used, this danger does not exist; each well can have a different level during the process of pumping.

Advantages

The method made it possible to obtain water from parts of the dune area which the construction of a horizontal drainage system would have otherwise rendered useless. It was also possible for the Leyden Dunewater Co. to control approximately 800 instead of 600 ha. of sand dune area with the result that, including the irrigation water, sufficient upper water is available to supply the whole service area. It appears that one well is equal to 100 m. of a drainage system. The pumps in the wells can be controlled from the water tower. The water is conducted to the rapid filters by a 300-mm. asbestos-cement pipeline. About 70 of these wells have been in use for 14 years without any difficulties.

Construction costs were only about 5 per cent of those of a closed, horizontal drainage system with the same capacity. An important additional advantage is the saving of water during the winter period.



Analytical Instruments Used in the Modern Water Plant Laboratory

By S. K. Love

A paper presented on May 1, 1951, at the Annual Conference, Miami, by S. K. Love, Chief, Quality of Water Branch, U.S. Geological Survey, Washington, D.C.

THE inventive genius of man has given civilization the great multitude of devices which have made possible higher standards of living and relegated to mechanical apparatus, much of the physical work previously performed by human beings. What is generally true of civilization, is also true of the analytical laboratory—but in a specialized way.

For many years, the acme of analytical perfection was the development of chemical procedures of the precipitate, wash, dry and weigh variety that would be highly accurate and precise. Time and labor requirements were relatively unimportant, but skill was essential for many of the complex, and often tedious, procedures. The balance, drying oven, muffle furnace and hot plate were regarded as essential, while other devices were tolerated. But radically new instruments were regarded as the lazy analyst's crutch or, at best, a poor substitute for tried and true methods of chemical analysis. Some even called these new contraptions inventions of the devil.

Trend Toward Accuracy

During the past two or three decades, there has been an accelerated development of instruments not only to perform various analyses more quickly but also more accurately. In the early stages of this development, most of the instruments were considered primarily as research accessories and were found almost always in research laboratories. But gradually their time- and money-saving features led to their widespread adoption and use in analytical laboratories of all kinds, including those of water plants.

Most of the larger and many of the smaller water plant laboratories procured various kinds of instruments best suited to problems and conditions existing at each installation. There are, however, a great many plants that have obtained few modern instruments for use in laboratory control of water served to the public.

The reasons that more instruments have not been provided usually include one or more of the following:

1. Lack of knowledge of application of instruments and their adaptability in water plant laboratories.

2. Inability to convince plant superintendents or those in charge of budget matters that the recommended instruments will pay for themselves in time saved or in increased accuracy of results.

3. High initial cost of the instruments.

4. Shortage of technically trained personnel capable of operating and maintaining the instruments.

Previous Studies

One of the most comprehensive reviews on use of instruments in chemical analysis was compiled in 1941 by Müller (1). This paper covered the whole field of analysis and described, in considerable detail, a great variety of analytical instruments—including principles of construction, operation and application.

A more recent report on instrumental analysis was published in 1948 by Willard, Merritt and Dean (2). That paper discusses briefly a group of instruments which were being used in water plant laboratories and which were found to be indispensable in the day-to-day operation of the plants and in conducting research on problems related to plant operation.

Graham (3) conducted a survey in 1945 of analytical practices in various types of water laboratories. Of the 41 laboratories reporting, only 11 represented municipal water plants. This group can hardly be considered a representative cross section of water plant laboratories. It is nevertheless significant that among the reporting laboratories 37 used pH meters, 24 used colorimeters, 17 used photoelectric photometers, 30 used centrifuges, 31 used the Jackson candle turbidimeter and 12 used the Hellige turbidimeter.*

pH Meter

In practically all water plants, it is necessary to determine pH in the laboratory and usually at one or more locations in the water system. It was long the custom to determine pH in the laboratory by visually comparing the color developed by using various indicator solutions that were made up for the purpose. Although reliable results can be obtained by this method, indicator solutions have a tendency to deteriorate gradually, so the analyst must make frequent checks on stability.

An improvement in the visual colorimetric determination was provided by the introduction of permanent standards, usually made of colored glass discs. These discs ordinarily cover the pH color range of a specific indicator. In use, the color in the water sample must still be developed by introducing the appropriate indicator solution in the water. Although the indicator solution is still susceptible to deterioration, the comparators with the permanent glass disc standards are popular, widely used and relatively inexpensive, as well as generally superior to liquid standards.

A later development has been the electron tube pH meters using glass electrodes. They give reliable results over long periods of time and require a minimum of attention. The first electronic pH meters were battery operated, and instruments of this type are still available and widely used, although the line-operated meters are recommended for routine use. Complete coverage of the pH scale is provided either in a single pH range of 1–14 or in two overlapping pH ranges of 1–8 and 6–14. Standard solutions of constant pH value are available or can be prepared to serve as check points at suitable places on the scale. Directions for making up reference solutions are given by Bates (4).

Various forms of continuously indicating or recording pH meters are a part of practically all large water plants. They show or record the pH of the water delivered to the mains and

* Product of Hellige, Inc., Long Island City, N.Y.

at various points within the plant where extensive treatment is applied.

Conductance Bridge

A conductance bridge is an instrument designed to measure the ability of a solution to conduct an electric current. This information is itself of little use to the water analyst. Values of electrical conductance become meaningful, however, when it is realized that there is a direct relation between the electrical conductance of a water and the amount of mineral solids dissolved in it. Intermittent or continuous conductance values are especially useful for water supplies that are taken directly from streams that show rapid changes in concentration of dissolved mineral solids. It is frequently possible to relate changes in electrical conductance to changes in treatment with little or no further analysis. Such changes in treatment may be accomplished manually or automatically.

The conductance bridge is a form of Wheatstone bridge in which the resistance of the water is balanced against a known resistance. Instruments suitable for water plant use can be purchased complete or may be made up from standard parts.

Modified conductance bridges are familiar instruments in many laboratories to check the purity of distilled or demineralized water. They are designed to measure extremely high resistances such as those encountered in very pure water, and they are not suitable for use in water containing appreciable quantities of dissolved solids.

Colorimeter

Colorimeters have been used in water laboratories for a long time. They are employed to determine the concentration of a substance by comparing its color, or the color developed by the addition of a suitable reagent, with the color of a standard. The method is very sensitive for many substances, and the instruments can be surprisingly simple. In the water laboratory, the simplest and oldest variety of colorimeter is merely a rack for holding Nessler tubes.

White light ordinarily is passed through the tubes or cells of both the sample and the standard to make the comparison. If colored or filtered light is used, the technique is called photometry. Most comparisons made with colorimeters can also be made with photometers, although the contrary is not necessarily true.

Colorimeters are used for such determinations as pH, ammonia, nitrite, nitrate, iron, silica, fluoride and phosphate.

Photometer

There are many types of photometers available for wide application in analytical procedures. A photometer is basically an instrument by which light intensities can be compared. The light may come from different sources or from a common source. For all colored substances, it is necessary to use filters to restrict the light to a narrow region of the spectrum.

Photometers using filters are called filter photometers of which there are two general types: visual and photoelectric. Visual filter photometers depend upon the eye to match two beams of light and are therefore greatly affected by the personal element. Photoelectric photometers are of many types and variations which have been ably classified by Müller (5). They

are usually more sensitive and more accurate than the visual kind.

Filter photometers are suitable for a wide variety of colorimetric determinations, including those for alkalinity, iron, nitrite, nitrate, copper, lead, manganese, silica, fluoride and phosphate.

Spectrophotometer

Spectrophotometers are capable of measuring the amount of light absorbed or reflected at each wave length throughout the spectrum. They differ drastically from filter photometers in that light of a given wave length can be produced by means of a prism or a diffraction grating, whereas in a filter photometer a different filter has to be used for each narrow region of the spectrum employed in colorimetric analysis.

Spectrophotometers find wide application in colorimetric analysis. They can be equipped with quartz prisms which permit measurements in the ultraviolet range, or with high grade optical glass prisms which restrict measurements essentially to the visible portion of the spectrum. Very narrow spectral bands, approximately monochromatic, can be obtained with the spectrophotometer.

This device can do all that a photometer can, but with greater accuracy and reliability. It can also be used for certain determinations to which the photometer is not adapted. Almost all colorimetric determinations can be made with a spectrophotometer. For a water plant laboratory, these determinations could include silica, iron, manganese, magnesium, nitrite, nitrate, fluoride, phosphate and possibly other constituents dissolved in water.

Although the spectrophotometer is more expensive than the filter photometer, many laboratories are convinced that its greater flexibility and reliability compensate for the additional cost.

Flame Photometer

There has recently been developed an instrument called the flame photometer which applies the established principle of spectrography, that elemental substances emit characteristic spectra when heated. In the flame photometer, the sample of water is drawn through a capillary into an atomizer burner and sprayed into a hot flame, where the spectral lines of the elements are excited. These lines are isolated and used as light sources, the intensities of which are measured. The intensity values are proportional to the quantities of the elements present.

The flame photometer can be used to determine sodium, potassium and lithium with high accuracy, within 0.1 ppm. or less. Calcium and magnesium are determined less precisely, but with sufficient accuracy for the needs of the average water plant.

It is for the determination of sodium and potassium that the flame photometer appears to have widest application. These elements could heretofore be determined only with considerable care and after considerable time. With the flame photometer, a determination can be made in five minutes or less. Although a nontechnical person can be taught to operate a flame photometer, it is essential that trained personnel be available to check the instrument frequently and maintain it in proper operating order. It is not foolproof.

Flame photometers are of two general types—an attachment to a high precision quartz spectrophotometer or a complete instrument by itself.

Residual Chlorine Analyzer

The orthotolidine test for chlorine residuals in water is familiar to all water plant operators. Because this reagent does not react with combined residual chlorine (chloramine), the orthotolidine-arsenite test was developed. This test is widely used and generally gives reasonably accurate results. It is, however, often erratic and therefore leaves much to be desired.

A new amperometric procedure and instrument were developed in 1942 by Marks and Glass (6) and further improved by Marks and Bannister (7) in 1947. The method is based on the principle of the polarograph, but employs specially designed electrodes to permit the determination of both free and combined residual chlorine in water. The instrument developed for this purpose utilizes the phenomenon of electrode polarization.

Amperometric Procedure

In using the amperometric procedure, the sample of water is titrated with standard sodium arsenite in neutral solution until further additions cause no change in current flow. This is the end point equivalent of free available chlorine. Potassium iodide is then added and the titration continued until there is again no change in current flow. This second titration offers a measure of the combined chlorine residual.

The amperometric procedure, using sodium arsenite as a reducing agent, is both accurate and fast. It also has the advantage of measuring both free and combined chlorine residuals in the same sample, but it is necessary to make the titration in a neutral solution. There are times, however, when it is desirable to carry out the titration at other pH levels. For this purpose the reducing agent phenylarsene oxide has been found to be very satisfactory, and it is recommended for all residual chlorine amperometric titrations in place of sodium arsenite. With the phenylarsene oxide, it is possible to differentiate between monochloramines and dichloramines, as well as to distinguish between free and combined residual chlorine. Details of the procedure and supporting data were reported by Marks, Williams and Glasgow (8).

Amperometric Recorders

To obtain a continuous record of residual chlorine at one or several points in a water supply system, automatic amperometric recorders have been developed and installed in several cities and appear to be giving satisfactory results. They must, however, be checked at regular intervals against laboratory determinations.

Although automatic residual chlorine recorders are valuable in providing continuous records and in relieving the chemist of part of the routine laboratory determinations, there has been a need for an instrument to go a step further —an automatic residual chlorine controller which would measure the amount of free chlorine present and automatically adjust the dosage to compensate for changes in chlorine.

Automatic Chlorine Controllers

One of the first successful automatic residual chlorine controllers was developed by Harrington (9) for the water treatment plant in Montreal, Que. It employed photocells of the barrier-layer type in an electronic circuit so that the color developed by orthotolidine was proportional to the residual chlorine. Changes in residual caused

by changes in chlorine demand were made to operate the automatic chlorination unit.

Improved equipment of this kind was developed by Caldwell (10) for use in the municipal plant at Springfield, Ill., and by Gray and Moses (11) for use in an industrial plant at Belle, W.Va. It is understood that all of the automatic residual chlorine controllers are specially fabricated for use in individual plants, and that they are not available commercially as complete units.

Spectrograph

The spectrograph is an expensive instrument and, to produce reliable results, requires a well trained operator. It is fundamentally an instrument designed to vaporize a small amount of solid material in a flame, arc or spark. The emitted light, which is characteristic for each element present, is dispersed on passing through a quartz prism or by a grating. Each band or spectral line is then photographed, and the elements can be identified by the location of the bands in the spectrum. The relative amount of each element present can be determined by the density of the spectral band.

In the hands of an experienced operator, the spectrograph can be used to determine extremely small quantities of many of the elements commonly found in water. Simultaneous determinations can often be made of several elements present in solution. Elements are often detected that were not even suspected, and which would have escaped notice in ordinary analysis. Of course, very few water plant laboratories are called upon to make complete mineral analyses, including trace elements. Consequently, the spectrograph is not likely to find popular use or application in the average water plant laboratory.

The Analytical Balance

The analytical balance is one of the oldest and best known instruments in the laboratory. A discussion of the common type of balances is not required here. Mention should be made, however, of the relatively recent development of a balance employing a different principle. It is so constructed as to weigh at constant load instead of at variable loads, as is done by the conventional type of balance. Because of this feature, the sensitivity of the new balance remains constant. Weights are removed in weighing an object. The weight manipulation is entirely mechanical, thus precluding the actual handling of weights. Weights of less than 100 mg. are indicated automatically.

Weighing with the direct reading balance requires 20–30 seconds, which is much less than with a standard balance. If a large number of routine weighings are made, this type of balance will pay for itself in a relatively short time.

Turbidimeter

The turbidity of water is a determination that is made by the great majority of water plant laboratories for which surface water is the source of supply. According to *Standard Methods,* the Jackson candle turbidimeter is the standard instrument for measuring turbidity (12). This instrument is well known and does not need to be described here.

Although the Jackson turbidimeter is widely used, many laboratories are using instruments in which the intensity

of the light that is scattered laterally may be compared with a suitable reference. In one instrument of this type, the twin photometric field is produced by the lateral illumination of the suspension and compared with a beam which is reflected upward through the suspension. A calibration curve must be prepared using standard reference suspensions which can be purchased or can be made up from specially prepared diatomaceous earth.

It seems pertinent to quote a fact mentioned in *Standard Methods* (12) that is not fully comprehended by many water plant chemists and operators. This fact is that turbidimeters measure turbidity, which is an expression of an optical approximation of suspended matter. The instruments do not directly measure suspended matter, which is the residue on evaporation of nonsoluble substances in the sample.

In addition to determining the turbidity of water, turbidimeters are frequently used to determine sulfate. In order to obtain reliable results, careful attention must be given to uniform procedure in the preparation of samples and standards.

Electron Microscope

Only two water plant laboratories are known to have electron microscopes. One is in the South District Filtration Plant in Chicago and the other in the Metropolitan Water District of Southern California. Although it is doubtful whether this instrument will ever be used in more than a few laboratories, it is interesting to find that it has been used successfully in the study of bacterial organisms and the structure of flocs formed in coagulation. Examination of over 5,000 routine samples has shown that there are a number of enteric organisms that are so closely related to the coliform group that they are impossible to segregate or differentiate accurately into genera or species.* It is suggested that if the identification of organisms closely related to *Esch. coli* and *Aer. aerogenes* is considered significant in maintaining water safety and purity, the electron microscope will be valuable in indicating the presence of these organisms.

Polarograph

The polarograph has not been used extensively in water plant laboratories in this country. Its use has apparently been limited to the determination of dissolved oxygen. Other determinations reported in foreign publications include heavy metals, nitrate and alkali metals in natural waters.

The polarograph is an instrument from which current-voltage curves can be obtained by electrolyzing a solution that can be electro-oxidized or electro-reduced between two electrodes. One electrode consists of dropping mercury and the other a nonpolarized pool of mercury or any other suitable reference electrode. Both qualitative and quantitative determinations can be made in one operation. The polarograph should find application in the water laboratory in the determination of iron, copper, lead, aluminum, zinc, nitrate, dissolved oxygen and possibly other constituents.

The main use of polarography in the field of water analysis at present is not in the polarograph as originally developed, but in a specially designed instrument that determines residual chlorine amperometrically (see p. 736).

* Private communication from John R. Baylis.

Radioactivity Monitoring Systems

Interest in the development of radioactivity measuring systems, capable of monitoring public water supplies, has increased rapidly during the past year. With the increasing possibility of pollution of water supply systems, from either an atomic bomb burst or the disposal of radioactive waste materials, the need for suitable equipment to detect and measure the intensity of radioactivity is becoming urgent. Civil defense officials, water utility operators and public health officers, as well as the general public, are all concerned with adequate facilities to determine when and how much contamination is caused by radioactive substances.

All natural waters are slightly radioactive. In another paper by the author (13), it was stated that ordinary surface and ground waters possess radioactivity in the range of from about 2×10^{-13} to 10×10^{-12} curie per liter (cpl.) This natural activity is so low that it cannot be detected by any known type of continuous flow equipment; it is also far below the danger level for humans or animals. The present generally accepted tolerance for mixed fission products in water is 10^{-7} μc. per ml. (14), or 100×10^{-12} cpl.

Former Practices

Until recently, in order to detect and measure the radioactivity present in water, it was necessary to collect samples for laboratory examination. It is now possible to obtain monitors designed expressly for use in public water supply systems that will make continuous permanent records of radioactivity caused by any significant amounts of radioactive materials added to the water. These monitors are designed to record the beta and gamma radiation, which are the types most likely to be present after a bomb burst. Auxiliary equipment is available to measure alpha radiation, either on spot samples collected manually or by registering the activity in a continuous belt of filter paper that is passed through the water and then brought under the detector.

The beta-gamma monitor consists of a specially made Geiger-Mueller tube which is mounted in a pipe or instrument through which the water passes, and connected to a suitable type of recorder chart. The equipment counts and records the normal background activity caused by cosmic rays. If additional radioactive materials enter the water, the recorder will indicate the intensity of the radioactivity present. To measure alpha radiation, one system uses a scintillation detector; another employs a nucleometer scaler.

A water monitor would most likely be located so that a stream of water from the plant effluent could be passed through it. Locations on the raw water intake or at points in the treated water storage system might be selected for the installation of additional equipment.

Special Monitors

Special water monitors for recording radioactivity are so new that very little operating experience is available. Monitoring equipment has been installed at Chicago's South District Filtration Plant, where extensive tests are being made, and similar installations have been ordered in other cities. Manufacturers of these monitors are to be commended for entering this specialized field of radioactivity measuring instruments even though present equip-

TABLE 1

Partial List of Instruments for Use in Average Water Plant Laboratory

Type of Instrument	Use	Approx. Cost	Manufacturer
Balance (constant load type)	All weighings under 200 g.	$900–1,000	Fisher Scientific Co.*
Colorimeter	Fe, SiO_2, NH_3, NO_2, NO_3, PO_4	50–200	Bausch & Lomb Co. Hellige, Inc. Klett Mfg. Co. Spencer Lens Co.
Conductance bridge	Electrical conductance	150–250	Industrial Instruments Co. Leeds & Northrup Co. Arthur H. Thomas Co.
Filter photometer	Alkalinity, Fe, NO_2, NO_3, Cu, Pb, Mn, SiO_2, F, PO_4	150–250	Central Scientific Co. Fisher Scientific Co. Klett Mfg. Co. Photovolt Corp.
Flame photometer	Na, K, Li, Ca, Mg	800–1,500	A.O. Beckman Co. Perkins-Elmer Corp.
pH meter	pH, alkalinity	150–250	A.O. Beckman Co. Coleman Instruments, Inc. Leeds & Northrup Co. Photovolt Corp.
Radioactivity monitor (recording)	Alpha, beta, gamma radioactivity	600–2,500	Radiation Counter Labs. Tracerlab
Residual chlorine titrator	Residual chlorine (free and combined)	225	Wallace & Tiernan Co., Inc.
Spectrophotometer	Essentially all colorimetric determinations	700–1,200	A.O. Beckman Co. Central Scientific Co. Coleman Instruments, Inc.
Turbidimeter	Turbidity, SO_4	50–150	Hellige, Inc.

* Only American source; balance is of foreign make.

ment may soon become obsolete. The demand for continuous recording monitors is growing, and it appears likely that most of the larger and some of the more moderate sized water treatment plants will soon find it desirable to protect their supply systems with reliable measuring and recording devices.

In addition to the newly developed recording monitors, there are several types of monitors that are equipped with probes for making spot tests of radioactivity.

Miscellaneous Instruments

It is doubtful that all of the various instruments that have been described will be found in any one water plant laboratory. On the other hand, some instruments not listed are undoubtedly

used in many laboratories. In addition, some standard instruments, in themselves not considered complete items of equipment for water analysis, are commonplace in the average laboratory. These include galvanometers, ammeters, voltmeters, potentiometers, transformers, rectifiers, simple color comparator blocks and slides. Such instruments are familiar to all laboratory workers and therefore do not require discussion here.

Increasing Use of Instruments

There is a growing trend toward the use of automatic and semiautomatic instruments in the laboratory. An automatic titrator that was recently placed on the market is an example of the available equipment of this kind. With this instrument, it is possible to perform titrations involving neutralization, oxidation-reduction and precipitation—all automatically. Compensation for temperatures from 0° to 100°C. is provided.

More automatic instrumentation is to be found in industrial control laboratories than in water plant laboratories. The value of labor saving devices, plus the increase in accuracy to be obtained by substituting instrumental data for information which depends largely upon the human element, are causing an unmistakable trend toward the acquisition of more and better instruments in the average water plant laboratory.

Table 1 gives a partial list of instruments that are suitable for use in the average water plant laboratory. The approximate costs are based on current (May 1951) market prices and are for the types and models that would be of most practical use to a water chemist. No attempt is made to include higher priced models that are intended primarily for research. The list of manufacturers is not complete for all the instruments tabulated. Makers of other models can be found in the advertising sections of technical journals and in dealers' catalogs.

Conclusion

Although instrumentation is the order of the day, and its actual value for obtaining more reliable data has been demonstrated, a word of caution is offered to those who are inclined to believe that instruments are a complete substitute for brains. Very few instruments are foolproof. All are subject to wear and tear and will sooner or later need some repair. Many of the newer instruments are complex pieces of electronic equipment which need experts to repair them. It also requires a competent chemist to recognize instrument failures or the need for adjustment. Such faulty results are often best observed by checking instrumental analyses with those obtained by the chemist using conventional analytical procedures. To make most efficient use of instruments in the water plant laboratory, a balance must be developed between instrumentation itself and competent chemists and technicians to supervise and operate the instruments. When this balance is achieved the laboratory will yield the maximum service that can be expected of it.

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Discussion

By John R. Baylis

Engr. of Water Purification Bureau of Eng., Chicago, Ill.

When the writer was employed to take charge of the experimental filtration work for the city of Chicago in 1926, plans and estimate of the costs of the experimental plant had been prepared. The engineer estimated the bacteriological laboratory equipment would cost $150, and additional apparatus for an extensive research laboratory would cost $400. He evidently had in mind the equipment observed in very small filtration plants. The cost of the equipment first purchased for installation in a room in the pumping station prior to the construction of the experimental plant was over $3,000; the total cost of the laboratory equipment was more than $5,000.

The filtration plant design engineers of 25–40 years ago were largely responsible for many of our poorly designed and equipped laboratories. An 8 × 10-ft. room with meager equipment was regarded as extravagant for medium and small filtration plants. Such laboratory tests as were made were often conducted by employees with less than high school training. If they could make turbidity, alkalinity and residual chlorine tests, and in some places do limited bacteriological work, they were considered capable.

Modern Improvements

Great strides have been made since then. Laboratories with ample space and good equipment characterize modern filtration practice. The chemist and bacteriologists of even some small plants are well educated and trained in water purification test methods. Some, not so highly educated, have carried on the study of laboratory testing, availed themselves of short courses and studied at night, until they have gained the necessary knowledge of water purification techniques. These operators are availing themselves of the latest equipment that aids in the more efficient performance of their work.

The author has rendered valuable service by calling attention to developments in the instrumentation of our water plant laboratories. This discussion will be confined to presenting a list of some of the laboratory equipment in the Chicago filtration plant laboratories. All the equipment mentioned is not new in laboratories, and some of it has been used for many years in a few of the water laboratories. It is not arranged in any special order. Equipment common to most laboratories is not mentioned.

Stirring Machines

The laboratories are equipped with three No. OL-147 stirring machines,* each with six stirrers. The machines are used for coagulation experiments and certain chemical analyses.

pH Meters

There are in use two Beckman Model M universal pH meters † with glass electrodes. These meters are used in making pH tests on water and are operated quite extensively.

Granular Activated Carbon Filter

The granular activated carbon filter consists of a pyrex glass tube, 5 ft. long and 6 in. od., mounted on a pipe base. The tube is filled with a column 3.5–4.0 ft. deep of granular activated carbon. This device is used to prepare odor-free dilution water for odor testing and is used almost constantly.

Laboratory Sand Filter

This instrument is a glass tube filter, 5 ft. long and approximately 1½ in. id. It contains 24 in. of sand, the same as the amount used in the actual filters. Untreated raw water is filtered through the unit constantly to determine the clogging rate.

Amperometric Titrator

The Amperometric Titrator ‡ is used to determine both free and combined residual chlorine in the same sample. It is more accurate than the orthotolidine-arsenite (OTA) or starch-iodide method. The instrument has good reproducibility and minimizes the human factor of interpretation. Briefly, it consists of a chlorine-sensitive cell and an ammeter. The sample is titrated with standard sodium arsenite until the end point, at which the needle becomes static. To determine combined chlorine, a few drops of potassium iodide solution are added to the sample at this point, and titration is continued until the needle again becomes static. Results in pounds per million gallons, are read directly from the burette. The instrument is used several times an hour in the chemical control laboratory.

Lumetron

The Lumetron § is a photoelectric instrument used regularly in the control laboratory for the determination of turbidity and occasionally for chlorine residuals with the OTA method. Although it receives rough treatment, it continues to give satisfactory performance. It has the advantage of a long light path (150 mm.), so that turbidities from 1.0 to 50 ppm. can be read and reproduced accurately.

* A product of Omega Machine Co., Providence, R.I.

† A product of A.O. Beckman Co., South Pasadena, Calif.

‡ A product of Wallace and Tiernan Co., Inc., Newark, N.J.

§ A product of Photovolt Corp., New York, N.Y.

Colorimeter

The Klett-Summerson colorimeter * has found its place in the laboratory for such routine analyses as those for NO_3, phenols and turbidities, in which broad band widths and long cell path can be combined. This instrument is put into use approximately 25 times every day.

Photolometer

The Photolometer † is a photoelectric instrument that is used for routine analyses, such as those for SiO_2, Mg, Mn and turbidities. It would be a valuable instrument for a small laboratory that cannot buy the more expensive spectrophotometer. It is used approximately ten times a day.

Residual Chlorine Recorders

The automatic residual chlorine recorder, as used at the filtration plant and pumping stations in Chicago, is an instrument based on an electrometric principle involving the depolarizing action of chlorine on a copper electrode. Seven of these units are now in service at the South District Filtration Plant and eleven are installed in pumping stations. As the units are composed of two separate parts, a cell and a Micromax ‡ recorder, it is possible to place the cells at almost any location in the plant and keep the recorders in the chemical control station.

The continuous recording of chlorine residuals has proved valuable in a number of ways. In addition to aiding control of prechlorination, the instruments indicate the possible need for postchlorination and permit maintenance of a constant safe residual in the water that leaves the filtration plant. The only disadvantage of this unit is that the cells function with a lower sensitivity when measuring chloramines. If chloramine treatment is continuous, however, the cell can be calibrated to record the free and combined chlorine proportionately. Changes in water temperature, pH, combined chlorine and iron contents, if above 3 ppm., influence the operation of the cell, although manganese, nitrites, nitrates and turbidity do not. The Micromax recorder has proved a practical instrument for measuring and recording voltage changes in electrolytic cells for a number of years and has given little trouble in operation.

Centrifuge

A Size No. 2 centrifuge is used to centrifuge various samples, and to concentrate bacteriological specimens for the electron microscopes.

Extractors

There are two extractors in use. Their purpose is the determination of oil in water, such as samples from the lake and from industrial plants. These instruments also find extensive use.

Shaking Machine

The shaking machine is used to agitate up to eight samples under test.

Vacuum Pump

This machine produces high vacuums for general use.

Spectrophotometers

The Beckman quartz spectrophotometer, Model Du § is used for col-

* A product of the Klett Mfg. Co., New York, N.Y.

† A product of Central Scientific Co., Chicago, Ill.

‡ A product of Leeds and Northrup Co.

§ A product of A.O. Beckman Co., South Pasadena, Calif.

orimetric analyses in which extreme accuracy and sensitivity are required. Absorption measurements can be made in the range of 320–1,000 mμ. Absorption cells of 10, 20 and 100 mm. are accommodated in an interchangeable cell compartment. Readings are given in both percentage of transmission and optical density. The instrument has been found to be valuable in determining the presence of the following substances in water: As, B, Cr, Cu, Fe, Pb, PO_4 and Zn. Approximately five determinations are made daily.

The Beckman flame spectrophotometer * is used in conjunction with the quartz spectrophotometer, enabling the analyst to measure the spectral emission intensity of the element being tested with the sensitive monochromator of the spectrophotometer. The flame attachment, as it is commonly called, consists of a burner and spray atomizer with appropriate connections and regulators for air, gas and oxygen. The burner is water-cooled. Approximately 5 ml. of sample are placed beneath the atomizer inlet tip. The air stream sweeps the sample through the atomizer to an electrically heated, jacketed spray evaporation chamber where the spray is dried. The sample then enters the burner flame in the form of microscopic particles through tubes adjacent to the fuel jets. The energy emission intensity of the element under observation is measured in units of percentage transmittance with the spectrophotometer. The intensity is proportional to the concentration. This instrument has been found to give excellent results quickly and accurately. It is used for such determinations as Na, K, Ca and Li and is used one to several times daily.

* A product of A.O. Beckman Co.

Electron Microscope

The console type electron microscope (1) is being used in the water laboratory as a research instrument in studying bacteria and coagulation in water treatment control. In addition to trying to work out a quick method for testing for the presence of coliform organisms by examining samples from 24-hour presumptive lactose tubes, the researchers have been attempting to identify other related bacteria that are encountered in these samples. The latest series of 5,000 routine samples that were run on the electron microscope, in parallel with the standard method tests, indicated that the correlation was 97 per cent of the total number of samples examined. The agreement with the *Standard Methods* (2) positive samples, however, was only 84 per cent. The agreement with the *Standard Methods* negative samples was 98 per cent. By means of photographs and subsequent differentiation tests, a fair gallery of pictures to use in general identification have been established. This operation has indicated that there are a number of enteric organisms so closely related to the coliform groups that it is impossible to segregate or differentiate them accurately into genera or species. The samples which are delayed lactose fermenters consistently give trouble in identification. If identification of organisms closely related to *Esch. coli* and *Aer. aerogenes* comes to be considered more significant to water safety and purity, the electron microscope will be very valuable in indicating their presence. *Standard Methods* tests, as presently used, do not indicate the presence of organisms other than *Esch. coli* and *Aer. aerogenes*. In more than

half of the disagreements with *Standard Methods* tests, the electron microscope gave a positive test because of the presence of these organisms, but subsequent *Standard Methods* procedures gave negative results. The electron microscope is therefore now used only to supply quick indications of their presence. No positive or negative determinations are made, however, with the electron microscope as these are obtained by *Standard Methods* procedures.

The electron microscope has also been used to study coagulation. Specimens of the various types of floc have been photographed and studied to learn something of their structure.

High-Rate Evaporator

The high-rate evaporator that is used has a capacity of 10 l. per hour. It works under 28 in. of mercury and 4 psi. steam pressure. It will take 3-l. batches or a continuous flow. Its main function is to concentrate samples for radiological counts.

Radiological Water Monitor

In accordance with the present interest in radiological defense, the laboratory is experimenting with a water monitoring control instrument. The instrument consists of a jacketed Geiger-Mueller counter with an amplified rate counter and strip chart recorder. A constant stream of water from the plant effluent sampling line is passed through the instrument which, in turn, counts and records the normal background in the water. If additional radioactivity enters the water, the recorder quickly indicates the intensity of the radioactivity present. The tests are so far inconclusive, and further work will be necessary before the instrument is considered satisfactory or its limitations determined.

Radiological Proportional Counter

The laboratory is also experimenting with an alpha-beta-gamma proportional counter, Model PCl.* This unit is designed to handle such samples as evaporated salts, precipitates, ashed and mud samples. The instrument is purely a proportional counter with very good sensitivity.

Geiger Counter

A portable Geiger counter of the radiation meter type is also used by the laboratory, primarily for measurement of radioactivity of low intensity, and particularly as a monitoring instrument during and after handling radioactive materials in the laboratory. It is useful in checking apparatus and equipment for contamination by small amounts of radioactive materials.

Odor-Testing Device

A constant stream of water is heated and sprayed in a bell jar with a hole in the top for use in testing the odor. It is provided with a means of diluting the water with odor-free water for determination of odor threshold. The device, which is not commercially available, has been described in a recent paper (3).

Constant-Temperature Bath

A constant-temperature bath has a 0–50°C. range. It is used as a bacteriological incubator for culture tubes of samples of water collected on eve-

* A product of Nuclear Measurements Corp., Indianapolis, Ind.

ning and night shifts—principally for 100-ml. tubes. The tubes are incubated until transferred to the main incubator in the bacteriological laboratory.

Charlab

Charlab * is an automatic washer used quite extensively for washing glassware in the bacteriological laboratory.

Broth Tube Loader

A broth tube pump is used very extensively for loading culture tubes.

Foerst Centrifuge

The centrifuge is used for the concentration of microorganisms to make counts. This instrument receives extensive use.

Photographic Equipment

Complete equipment is available for regular photography and for making photomicrographs, including the equipment for developing and for printing. Much photographic work is involved in the use of the electron microscope.

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* A product of Eimer and Amend, New York, N. Y.

Relation of Water Utilities to State Regulatory Bodies

By Spencer B. Eddy

A paper presented on April 5, 1951, at the New York Section Meeting, Albany, N.Y., by Spencer B. Eddy, Commissioner, State Public Service Com., Albany, N.Y.

OF all the utilities with which a public service commission deals, the water industry is the oldest and the most essential. Necessary as the electric light and the telephone may be to the present economy and living standard, civilization can and did exist without them. Mankind cannot, however, exist without water.

Two thousand years ago the civilization of Rome depended upon the great aqueducts which were constructed to bring water to the cities. Some of these aqueducts were so well built that they are still in use. Because of an adequate water supply, the incidence of certain diseases and the resulting death rate in a Roman city two thousand years ago was far less than it was throughout the middle ages and until only a few years ago in Europe, England and even in this country.

In the state of New York there are approximately 920 water plants, of which 545 are owned by some subdivision of the government. There are 375 that are privately owned, and of these, 105 corporations operating 125 water works systems are under the supervision of the Public Service Commission. The present statute exempts any privately owned property worth less than $10,000 from P.S.C. control. The commission's control over water companies differs, however, from its control over other utilities.

Control of electric, gas and telephone companies by the P.S.C.—even those which are municipally owned—is, broadly speaking, complete. A more complicated pattern exists for the supervision of the water industry. There is no control whatsoever of municipally owned plants or privately owned plants having property worth less than $10,000. All water supply systems, whether publicly or privately owned, must obtain permission from the State Water and Control Commission to acquire a source of supply. The sanitary aspect, encompassing the healthfulness and purity of water, is largely controlled by the Health Department. The P.S.C. controls rates and service, and accounting and financing. No privately owned water company may dispose of its property without the commission's direct approval.

Differences From Other Utilities

The water industry is characterized by certain marked differences from other utilities:

1. The investment in a water plant is far greater in proportion to its annual revenues than it is in any other form of public utility.

2. Revenues are far more stable. Although business depressions greatly affect telephone use and even the sales of electricity and gas, they make very little difference, except possibly in some

industrial use, in the amount of water consumed.

3. There has been a tendency in the industry toward government ownership. An appreciable number of municipally operated electric plants have been sold by the municipalities to local power companies, but no municipality has disposed of its water works to an outside corporation. Many private water companies, on the other hand, have sold their plants to the municipalities which they served.

One reason for this tendency is that electricity can be transmitted cheaply and dispatched to the point at which it can be best and most economically used. With the exception of New York City, the water supply is almost exclusively a local problem, and construction and transmission costs make anything like the grid of interlocking electric lines which serve this state prohibitive. Also, with but few exceptions, the municipal systems in New York have been well run and have served the public adequately. The municipal system has certain advantages —particularly those of cheap financing and low taxes—not enjoyed by the privately owned companies, and a much stronger argument can therefore be presented for municipal ownership of water plants than for any other class of utilities.

Problems of Water Industry

Foremost among problems facing the water industry is the ever present question of rates. As long as the inflationary spiral exists, taxes increase and the costs of doing business rise, the necessity of rate relief can be lessened but not eliminated. The water companies most seriously affected by these factors are those that serve expanding communities requiring additional plant construction. It would have been necessary recently to have increased the plant investment of a small company serving 154 customers approximately 75 per cent to serve 11 additional customers in its territory. Service must, of course, be furnished to anyone who desires it, but serving additional customers may well necessitate increased rates to present customers—an increase which would not be necessary if the business were static. To solve this problem, a general investigation of present rules for extensions is being undertaken so that the views of the industry can be obtained. These views will form a basis for discussion, and it is hoped, will provide suggestions for equitable treatment of both the customers and the company.

Water conservation will aid in minimizing additional plant construction. It may previously have been more economical to have a leaky main than to repair or replace it. It is no longer so if additional water storage or pumping facilities must be added to provide for the wasted water. The most practical method of reducing water use is complete installation of meters. Material shortages during World War II rendered meters virtually unobtainable, and the same situation may soon again exist. Although exact figures are not available, estimates indicate a saving of as much as one-third by substitution of metered for unmetered service. Meter installation by a small company may require a substantial capital expenditure and thereby increase its operating expenses, but this outlay will be less than that required to build additional plant.

Sale of Water Systems

Companies have not always given adequate or proper service, sometimes

because of financial problems, sometimes because the existence of the company was not economically justified and sometimes because of a multitude of other reasons, including the owners' avarice. Such situations move customers being served to demand the acquisition of the plant by either the municipality or a water district to be created for that purpose. The P.S.C. has nothing to do with the creation of water districts; that operation lies within the jurisdiction of the state comptroller.

All too often the bad company providing poor service impels the community to overpay in ridding itself of an inadequate service. New York law requires that any utility, including privately owned water companies, must obtain the commission's approval before selling its plant. The law further requires that the P.S.C. must determine that the sale—including, of course, the price paid—is in the public interest. It is not, however, the municipality that is controlled by the P.S.C. The commission's control is solely over the property of the selling company. This law can nevertheless protect the community's interests since its control of one negotiator (the company) provides effective control of the entire negotiation.

It has been suggested that the statute be amended to give the commission jurisdiction over all water companies. The author feels that no new water company that is privately owned should be created without P.S.C. approval. This provision will protect homebuilders from the practices of real estate speculators who construct inadequate water systems only to stimulate land sales. Such systems function satisfactorily for a short time and thus attract customers, but after the development is completed they break down, leaving the homeowners with practically worthless property—or further costs in providing a new system that will function properly.

Future Prospects

The most optimistic view of the future forecasts a period during which the defense effort will render many supplies increasingly difficult to obtain, raise manpower problems, including the loss of key personnel to the armed forces, and precipitate wage and price increases. A more serious view portends an imminent fight for survival to preserve not only *our* way of life but civilization as it is now known.

No other industry will face more ponderous problems than those of the water industry. No industry is more vulnerable to sabotage. A water plant destroyed or a supply contaminated cannot be quickly restored. Not only the enjoyment of normal living conditions, but the health and lives of the nation's people rest in the hands of water works operators.

Fluoride Chemical Feeding

By L. E. Harper

A contribution to the Journal by L. E. Harper, Pres., Omega Machine Co., Providence, R.I.

FLUORIDATION of public water supplies to obtain a reduction of dental caries for consumers has been the subject of much study since the Newburgh-Kingston experiments were started. Interest has increased as the favorable results of this and other controlled experiments at Grand Rapids, Sheboygan, Evanston and other cities have been published. The subject has been well covered from chemical, biological, legal, ethical, health and cost standpoints, particularly in recent papers by Maier (1), Faber (2) and Cox and Ast (3). This discussion is devoted exclusively to the physical plant and the practical problems involved in fluoridation.

Individuality of Systems

There is no single chemical or system of handling and feeding fluoride compounds that is best for all conditions and all sizes of plants. The equipment and chemical recommended depend on the size of the plant, whether or not the supply is enclosed and under pressure at the point of application (as in most small well supplies), the number of application points, the cost of fluoride compounds in the particular locality, whether or not the installation has been planned for an existing plant or a new one and personal preferences.

Chemicals

The appendix contains basic data for the sodium silicofluoride, sodium fluoride and hydrofluosilicic acid. This information is essential to provide an understanding of the handling and feeding of these materials.

Table 1 shows the characteristics of the most generally used fluoride compounds and their prices as of June 1951.

Table 2 shows the cost per year, for chemicals only, to increase the fluoride content 1 ppm. in plants of capacities from 0.1 to 10 mgd. Costs for intermediate or larger capacities may be obtained by using the value for 1 mgd. and the proper multipliers.

Table 3 lists the chemical companies which produce the three basic fluoridation chemicals. It will be noted that the new chemical "Flural*" ($AlFSO_4$) is not included in these tables. It has been omitted because its use is still under laboratory study.

*An experimental product of Ozark-Mahoning Co., Tulsa, Okla. Flural has the appearance of granular alum and is intended to be fed in an alum feeder. The fluoride content can be adjusted relative to the alum content so that normal alum treatment of any water will give proper fluoride dosage. A second alum feeder for standard alum should be used during periods of greater requirements. Flural is said to be cheaper than alum plus sodium fluoride.

TABLE 1

Characteristics of Fluoride Compounds (1)

Chemical	Formula	Purity *per cent*	F Content *per cent*	Solubility at 25° C. *g./100 ml.*	Cost per lb.	Cost per lb. Available F	1 ppm. F Treatment of 1 mil.gal.	
					cents		Cost *dollars*	Quantity *lb.*
Sodium Silicofluoride	Na_2SiF_6	98.5	60.0	0.762	5.6	9.33	0.78	13.9
Sodium Fluoride	NaF	95–98	44.4	4.050	11.0	25.0 (28.0 coarse)	2.15	19.5
Hydrofluosilicic Acid*	H_2SiF_6	30.0	22–30	Liquid	7.8	32.90	2.94	36.3 23% basis

* Competent authorities state that hydrofluosilicic acid can be recovered as a byproduct of superphosphate fertilizer manufacture, at a cost competitive with silicofluoride when sold in tank car lots on a long contract basis. There is none available at present.

Basic Installation Requirements

A quick glance at Table 1 may evoke the question, "Why use any but the cheapest chemical—silicofluoride?" For economic reasons, large cities should obviously not consider the more expensive forms. For the small plant, however, several factors such as equipment cost, desirability of using proportioning pumps for pressure feeding, distance from source of supply and space available for equipment affect the choice of compounds. Another factor is the current shortage of silicofluoride, although there will eventually be enough, as there are ample sources.

A very small plant can, of course, afford to be less concerned with the price of the chemical than with the purchase and maintenance costs of the equipment required to apply it. In a very small plant the handling problem is also minimized. Although it is ideal to have handling made convenient in the smaller plants, the time and attention given to this portion of the planning may be secondary. A small plant may use only 100 lb. of fluoride compound per month. If this 100-lb. container must be carried up a flight of stairs once a month the onerous task may not be desirable, but it is certainly not comparable to the hardship in a plant where the feeding rate may be several hundred pounds daily, or even 100 lb. per day.

Space Limitations

The majority of fluoride installations to be provided in the next several years will be constructed in existing plants which were built before fluoridation was even known. In these it may be difficult to provide an ideal installation, simply because of space limitations. In planning fluoride feeder installations, as in any similar engineering problem, some compromise between the ideal and the practicable is frequently necessary. The recommendations in this paper are based on what has proved to be best in practice.

The closer these precepts are followed, the better the installation will be—the more they are disregarded or compromised, the poorer the installation will be. It is not implied that an installation that fails to comply with these recommendations will not work. A workable installation might indeed

TABLE 2

*Annual Chemical Costs of 1-ppm. Fluoridation**

Chemical	Average Production—*mgd.*						
	0.10	0.25	0.50	1.0	2.0	5.0	10.0
Sodium Silicofluoride	$ 28.50	$ 71.25	$142.50	$ 285.00	$ 570.00	$1,425.00	$ 2,850.00
Sodium Fluoride	76.50	191.25	382.50	765.00	1,530.00	3,825.00	7,650.00
Hydrofluosilicic Acid	100.00	250.00	500.00	1,000.00	2,000.00	5,000.00	10,000.00

* Based on June 1951 cost data.

be obtained if every suggestion offered here is ignored. It will, however, be a marginally operating installation, plagued by high maintenance costs, labor and material wastes, and improper dosing.

Factors Governing Choice

After chemical costs and basic physical requirements are considered, it is desirable to evaluate the types of installations which may be chosen.

A fluoridation installation must be viewed as an entity and examined in all its aspects. The best installation may be defined as one that incorporates the best combination of the following factors:

1. Simple mechanical feeding device, either liquid or dry.
2. Simple piping or injection arrangement. (Gravity feed is less complicated than pressure feed.)
3. Minimum chemical handling.
4. Minimum maintenance and operational duties.
5. Minimum equipment expenditure consistent with good performance.
6. Means for maintaining a reliable permanent record.

Types of Installations

The various systems or types of installations available are listed below, with their advantages and limitations. The six conditions mentioned above must be considered in evaluating the suitability of these systems for any particular plant. Chemical cost is not a factor in this listing, although it does affect one's viewpoint. Simplicity is the watchword.

1. Rubber or plastic diaphragm type proportioning pump, delivering hydrofluosilicic acid by gravity directly from the acid container on scales to the point of application.

This type of installation requires minimum chemical handling. Diaphragm proportioning pumps are generally preferable to piston or plunger type pumps because of their lower maintenance requirements and greater simplicity. They will pump against 100 psi. but are limited to a capacity of approximately 7½ gph. for a single unit, or 15 gph. for a duplex pump.

Treatment with 7 gal. of fluosilicic acid will add 1 ppm. of fluoride ion to approximately 2 mil.gal. of water. Hydrofluosilicic acid or solution feeding is presently confined to the smaller plants or if feeding against pressure is necessary. Should cost of the acid come down, however, it might be purchased in carload lots and pumped to storage. A diaphragm pump or dipper type liquid feeder could then be used

TABLE 3

Fluoride Chemical Supply Sources

Silicofluoride

Blockson Chemical Co.
Joliet, Ill.

Davison Chemical Co.
Baltimore 3, Md.

E. I. du Pont De Nemours & Co.
Wilmington 98, Del.

U.S. Phosphoric Products Co.
Tampa, Fla.

Baugh Chemical Co.
Baltimore, Md.

Henry Sundheimer Co.
103 Park Ave.
New York 17, N.Y.

Sodium Fluoride

Blockson Chemical Co.
Joliet, Ill.

General Chemical Div.
Allied Chemical & Dye Corp.
40 Rector St.
New York 6, N.Y.

Aluminum Co. of America
Chemicals Div.
624 Gulf Bldg.
Pittsburgh 19, Pa.

American Agricultural Chemical Co.
50 Church St.
New York City, N.Y.

Hydrofluosilicic Acid

Davison Chemical Co.
Baltimore 3, Md.

Harshaw Chemical Co.
1945 E 97 St.
Cleveland, Ohio

E. I. du Pont De Nemours & Co.
Organic Chemicals Dept.
Philadelphia, Pa.

Baugh Chemical Co.
Baltimore 3, Md.

to measure the acid to the point of application. This could result in minimum chemical handling and a very simple installation. At present, existing customers are using all the fluosilicic acid produced.

2. Dry feeder (on platform scale, or gravimetric weighing dry feeder) with dissolver, delivering sodium fluoride or silicofluoride solution by gravity to point of application.

Dry feeders are ordinarily used in most medium- and large-sized plants, or wherever gravity feed can be used. Volumetric feeders will deliver as little as 3–4 oz. per hour to treat supplies of 200,000 gal. or more daily. Gravimetric (weighing) dry feeders will feed as little as 1 lb. per hour but are generally used for rates of more than 5 lb. per hour or to treat supplies of 5 mil.gal. or more daily.

3. Diaphragm type proportioning pump for hydrofluosilicic acid, delivering directly from acid container on a platform scale to main, under pressure, through an injection nozzle.

If calcium and magnesium are present, they may deposit on and clog the nozzle, thereby further complicating high-pressure injection. Pressure feeding always involves additional equipment and more extensive maintenance than is required by gravity feed.

4a. Saturators for sodium fluoride with liquid feeder for gravity feed.

Saturators (4) have many advantages that favor their use in plants in which this system is applicable. The tanks may be placed at a low level to facilitate filling, and they may hold a comparatively large quantity of chemical. An entire 100-lb. bag or 125-lb. drum may be added at one filling. The granular sodium fluoride used in them is quite free from dust.

A saturator with a proportioning pump that uses a 4 per cent solution will treat 3 mgd. with 1 ppm. of fluoride. Duplex or triplex proportioning pumps can double or triple this capacity, respectively.

4b. Saturators for sodium fluoride with proportioning pumps for pressure feeding.

If hard water is encountered, the saturator makeup water must be softened thereby complicating the installation and increasing maintenance.

5. Dry feeders (on platform scales or gravimetric) with injector or pump to deliver against pressure.

If hard water is encountered, ejectors or pumps should not be used for rates which exceed approximately 12–20 lb. per day of sodium fluoride. Ejectors and pumps will clog excessively with calcium or magnesium fluoride unless the dissolver water is softened or calcium and magnesium are stabilized by polyphosphate treatment.

6a. Liquid feeders for feeding 3–4 per cent sodium fluoride solutions by gravity.

6b. Proportioning pumps for feeding sodium fluoride solutions against pressure.

Treatment with 7 gph. of 3 per cent sodium fluoride solution will add 1 ppm. of fluoride ion to approximately 90,000 gal. of water.

If hard water is encountered, a softener should be provided to make up the solution and prevent loss of fluoride which will precipitate out as magnesium or calcium fluoride.

In systems 6a and 6b, it is more complicated to measure both the sodium fluoride and water to make up a solution of known strength than simply to fill the hopper of a dry feeder or the tank of a saturator. If waters of high calcium and magnesium content are encountered, the softener is an added item of equipment requiring attention and further complicating the installation. The addition of phosphates involves handling additional chemical.

Receiving, Storing and Handling

The chemical must be moved into the plant and stored before being put into the feeder. The cost of this handling is just as important as the cost of the chemical itself. Chemical handling and storage may therefore logically be considered first. The requirements for small plants will be discussed first, with recommendations for larger plants following in size order.

Storage should be convenient to the feeder for any size plant. The chemical should be stored in a dry room, not directly on a concrete floor laid on the ground. Moisture can be absorbed through concrete flooring, and even steel drums should be placed on boards or grids to allow circulation of air to prevent "sweating" on the bottom.

Hydrofluosilicic Acid

If hydrofluosilicic acid is obtained in drums, they should be placed on a platform scale beside or below the proportioning pump, for convenience in checking the amount fed. As requirements will be low, only one or two drums will ordinarily be kept in storage. Standard two-wheeled, rubber-tired industrial hand trucks or special drum trucks provide an easy means of handling the drums.

Rubber gloves, goggles and rubber aprons should be worn by those handling drums.

This chemical should not be diluted as dilution may cause the silicic acid to gel. The diluted acid will also be more active. Pumps should be used in smaller plants for feeding the acid since they provide a closed system and can take their suction directly from the shipping container. The container should be placed on scales to check the

rate of feed. This method precludes the need for sampling or for any other handling of the acid.

Fluoride or Silicofluoride

If few in number, 100-lb. bags can be transported by hand trucks. Four or five 100-lb. bags, measuring 17 × 25 × 6½ in., can be stacked easily on a "stevedore" truck. Rubber tired trucks

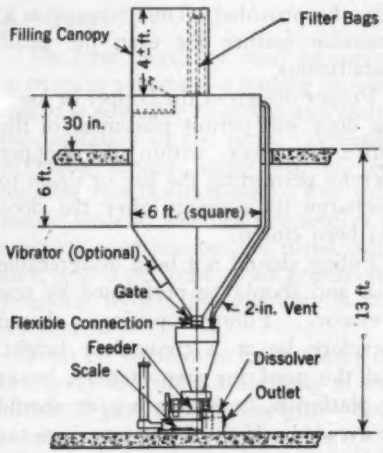

Fig. 1. Chemical Feeder and Storage Hopper

The hopper is installed above the feeder to save storage space. Although only 36 sq.ft. of floor space is used, approximately half a carload of fluoride compound is accommodated.

are easier to use and less damaging to floors.

If pressed for dry materials storage space, a storage hopper should be constructed above the feeder to hold the entire shipment of chemical. The floor-to-floor distance assumed in Fig. 1 is 13 ft. Since the hopper is a 6 ft. cube, it will hold 200 cu.ft., or approximately half a carload of fluoride compound and require only 36 sq.ft. of floor space.

Storage in bags requires floor space, whereas chemical storage hoppers can utilize overhead space not generally used. A bin gate or valve should be used for filling the smaller feeder hopper from the storage hopper. The feeder hopper should be vented back to the top of the storage hopper. This arrangement results in a single handling of the chemical and solves the problem of segregated storage. For dumping such large quantities of chemicals, adequate dust removal equipment must be provided.

If the dry chemical is to be stored and used in considerable quantities, such as carload shipments, good material handling practice may indicate pallet storage and transportation by dollies.

The size of elevators or doorways often determines pallet size. A 30 × 48-in. pallet having a platform height of 11 in. and holding 25 100-lb. bags, six bags high, with one in the center may be used. The total height from the floor will be 54 in. The advantage of pallet handling is that it decreases labor needs, dust and breakage.

In handling carloads or any large quantities of the fluoride compounds, operators should wear respirators.*

Barrels and large drums (350–450 lb.) are seldom used but may be desirable because of shipping limitations. Their weight may render them difficult to handle. They may be transported on the level with a two-wheel indus-

* Bureau of Mines mask BM2101 and filter BM2133 are recommended. They are available from Mine Safety Appliances Co., 232 N. Braddock Ave., Pittsburgh, Pa., and Davis Emergency Equipment Co., Inc., 45 Halleck St., Newark, N.J.

trial truck. An elevator or hoist is necessary if they are to be elevated or stored in tiers. Figure 2 illustrates the use of a dust canopy for filling a hopper from barrels or drums without escape of dust. A filter is necessary to prevent the escape of dust if more than one drum is to be emptied into the hopper.

Filling Feeder Hoppers

It is desirable, even in small installations, to provide hoppers for chemical feeders or dissolving tanks for liquid feeders and proportioning pumps that hold more than an entire container of chemical. For bags, this capacity is approximately 125 lb. to permit another 100-lb. bag to be unloaded into the hopper before it empties.

Fig. 2. Dust Canopy

Bags or barrels of chemical are enclosed by housing while being emptied into hopper thereby preventing the escape of any dust.

The advantages of this arrangement are:

1. Less handling of fluoride, with saving of time
2. Less dusting, with improved working conditions
3. Less chance of spilling, with savings of chemical.

If more than one bag is emptied at a time, or if large drums or barrels are emptied, dust removal equipment should be provided. A means of outside discharge from the dust filters must always be provided. Dust removal is a desirable feature for even the small installations.

Proper design of the hopper or loading door will permit placement of the entire container within the hopper thereby permitting the bag or drum to discharge its contents after the door has been closed.

Filling should not be a disagreeable task and should be performed by one operator. Filling openings should therefore be at a convenient height, and the need for step ladders, boxes or platforms, to fill the hopper should be avoided. If the filling openings are high, there is a tendency to transfer the chemical from the original container to a smaller one to facilitate lifting, thus causing spillage, excessive dusting and waste of time.

If the extension hoppers extend through the chemical storage floor above the feeders, it is often desirable to extend them as high as possible to increase the storage capacity. A convenient loading height is 24–30 in. The maximum height of 36 in. should be used only if quantities used are not too great. A convenient height if barrels or large drums are to be emptied is 12 in., as the edge of the hopper can be used as a fulcrum point to aid in upsetting the barrel.

If the extension hopper extends through the floor and takes space needed for aisles, as shown in Fig. 3, the hopper can be stopped flush with the floor.

Feeder Requirements

There are four basic requirements of feeders for fluoride chemicals: accuracy, dosage check, efficient dissolver and protection against overfeeding.

Accuracy

The term "accuracy" may be applied to so many aspects of a feeding problem that it is advisable to define and clarify the limitation of the term. Accuracy generally means uniformity of feed once the rate is established. For volumetric feeders, whether dry feeders or proportioning pumps, the usual tolerance is ± 3 per cent. For gravimetric weighing feeders the tolerance is ± 1 per cent.

Tests on volumetric feeders may occasionally indicate a uniformity of feed within 1 per cent by weight. Such accuracy can result if the density of the material has remained extremely uniform. Variations in weight per unit of volume may and do occur, however, because of: [1] compression of chemical by its own weight, piled in the hopper, [2] compression by vibration from other machinery or the feeder itself, [3] different flow characteristics caused by slight differences in moisture content or storage conditions and [4] variation in density or particle size between different shipments or even between different bags in the same shipment.

There are many other factors, but all manufacturers of chemical feeders generally know that under ideal conditions, with clean feeders the machines will deliver ± 1 per cent of the desired amount by volume. Manufacturers should not, however, be expected to stretch their consciences by guaranteeing accuracies closer than ± 3 per cent for volumetric feeders under field conditions.

"Accuracy" may also pertain to setting the rate of feed. Accuracy can be achieved most easily in volumetric feeders if the adjustment scale is linear and contains a large number of scale graduations. Closer settings may be made if the scale has 100 readable graduations than if there are only 10. The recommended type of linear scale is calibrated in percentages. If the scale is nonlinear, a calibration chart must be referred to when setting the rate of feed.

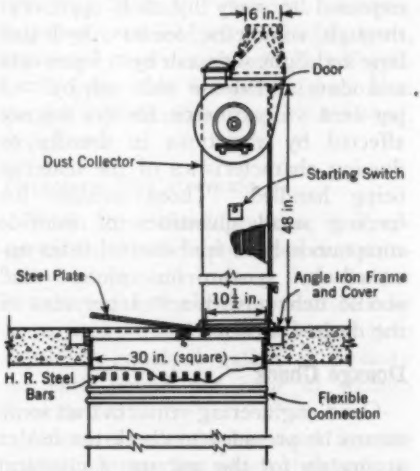

Fig. 3. Extension Hopper Design Variation

This extension hopper has been stopped flush with the floor to conserve aisle space. The dust collector can be turned through 180 deg. The angle iron frame and cover are set flush with the floor.

Volumetric feeders must be calibrated or tested on the particular chemical to be fed to determine the feed rate for a given setting. Gravimetric feeders should be capable of being preset exactly to the desired rate without calibration.

Accuracy of volumetric feeders is very closely related to a compressibility factor and to flow characteristics. The rate of feed of activated carbon, which is very compressible, may therefore be expected to vary by ± 10 per cent through volumetric feeders, hydrated lime and light soda ash by ± 5 per cent and alum and dense soda ash by ± 3 per cent. Gravimetric feeders are not affected by variations in density or flowing characteristics of the material being handled. Those suitable for feeding small quantities of fluoride compounds have feed control rates operated by synchronous motors and should deliver within ± 1 per cent of the desired amount.

Dosage Check

Good engineering requires that some means be provided to check the feeder accurately for the amount of chemical being delivered. Periodic sampling is not desirable for several reasons:

1. Fluoride chemicals (acid, dry or solution) should not be handled.
2. Test periods must be comparatively long or they are inaccurate.
3. Interruption of chemical dosage is undesirable.
4. The practice is time-consuming.
5. Over- or underfeed may occur between sampling periods without being detected.

Provisions for continuous testing are so inexpensive and simple to provide that they should not be omitted. This operation provides a means of keeping necessary records and more closely controlling plant operations.

If hydrofluosilicic acid is pumped by a proportioning pump to the application point, the original acid container can be placed on a platform scale and loss in weight read at convenient intervals. Beam scales are relatively inexpensive, and at a nominal expense they can be equipped with vernier indicators that make them dial scales with 100-oz. ranges. After 100 oz. has been fed, the tare weight is shifted. These indicators are especially recommended for very low feed rates (1½ lb. per hour or less). Dial scales, furthermore, cost about four times as much as beam scales.

Loss-in-weight type gravimetric feeders have built-in scales that control the feed rate. Chart recorders can easily be attached to gravimetric feeders.

If sodium fluoride solutions are to be pumped or measured by any other type feeder, several simple methods of continuous testing may be used. The simplest is a scale attached to the inside of the tank that can be easily read by the operator, although, for a deep tank, a float, cable, pulley and scale on the outside of the tank would be better. A sight glass will show the level in the tank at all times and, if connected to the tank and pump as shown in Fig. 4, will serve as a test gage to show how much the pump is delivering with each stroke. The gage will also indicate any malfunctioning of the valves. If the solution rises in the sight glass during a pressure stroke, the suction valve is faulty. If the proper volume is not drawn in by the pump, the discharge valve is at fault.

By providing a water meter on the makeup supply to a sodium fluoride

saturator, a record of the sodium fluoride used may be developed.

Dry feeders for low rates of feed should be placed on a platform scale as described above for acid tanks, and vernier indicators used to check the feed at low rates.

Dissolving Tanks

Dissolvers should not be placed on the scales of small feeders for two reasons:

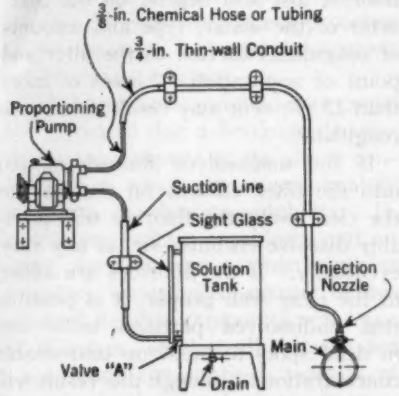

Fig. 4. Proportioning Pump Installation
When valve A *is closed the pump draws directly from the sight glass, showing the exact amount delivered by each pump stroke without interrupting the feed.*

1. When feeding a few ounces per hour, the slightly fluctuating level in the dissolver makes loss-in-weight tests unreliable, except for long runs.

2. Condensation on the dissolver increases in humid weather and runs down upon the scale thus increasing the weight on it.

Large dissolvers used for higher feed rates would also not be placed on scales because of their great weight.

Because fluoride compounds dissolve slowly and form very dilute solutions, dissolvers must provide ample retention time. Sodium fluoride is soluble to the extent of only slightly more than 4 per cent. Solubility tables are based on pure (distilled) water and unlimited solution time. Practical considerations of limited time and less than ideal conditions suggest that about one-fourth of the ultimate solubility, or 1 per cent, can be obtained in a continuous dissolver. A 1 per cent solution is obtained with approximately 12 gal. of water per pound of chemical. Assuming a rate of feed of 10 lb. per hour, the water requirements will be 120 gph. or 2 gpm. A five-minute retention period will therefore require a 10-gal. dissolver.

Dissolver Size Formula

From these considerations, it is apparent that, based upon 1 per cent solubility in five minutes, a formula for dissolver sizes for sodium fluoride may be written: dissolver size (volumetric capacity) equals 1 gallon of capacity for each pound per hour of sodium fluoride fed.

Dissolvers should be sized for the maximum rate for which they will be used. When operated at less than the maximum rate, the amount of water used is the same (or approximately the same) as at the maximum rate, since the power is required to stir the same volume of water. The solution leaving the dissolver is weaker at lower rates but this is not objectionable as no water is wasted. Only the power is extracted from the water to stir the dissolver.

Because very small jets tend to clog, and there is no economy in fabricating an extremely small dissolver, the smallest ones are made to hold about 5 gal. These units will dissolve a maximum of

approximately 5 lb. per hour of sodium fluoride or 2.2 lb. of fluoride ion per hr.

The same method may be used for computing the dissolver capacity for sodium silicofluoride. Based upon a solubility of 0.2 per cent (approximately 25 per cent of maximum) compared with 1 per cent for sodium fluoride, it is evident that five times as much water will be required or 5 gal. per pound per hour of silicofluoride fed. A

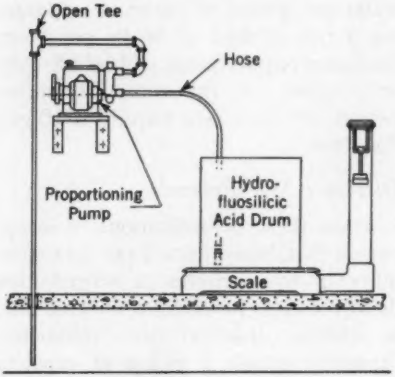

Fig. 5. Proportioning Pump Installation Variation

This arrangement is used when pumping to a lower level such as the flume below the floor, which is the treatment point in this installation. The open tee provides a break in the solution line to prevent siphonage.

5-gal. capacity dissolver is therefore suitable for dissolving approximately 1 lb. of sodium silicofluoride or 0.6 lb. of fluoride ion per hr.

If large quantities of dry fluoride compounds are fed (more than 20 lb. per hour), dissolvers which have two or more compartments through which the fluoride must pass in series, or adequate baffling, are advisable to prevent undissolved fluoride from making a short circuit through the outlet of the dissolver.

Efficient Dissolvers

These factors raise the question of the need for efficient dissolvers against feeding, for example, a slurry of sodium silicofluoride. If undissolved fluorides are fed before filtering, they will be retained by the filters until dissolved. This situation will result in the loss of some fluoride. The amount of fluoride lost will depend on the character of the water, type and amounts of coagulants carried to the filter and point of application. Losses of more than 25 per cent may result if fed with coagulants.

If the undissolved fluoride is fed into the filter effluent on the way to the clear well, the fluoride will probably dissolve enroute—or, at any rate, eventually. If the fluorides are added to the clear well proper, it is possible that undissolved particles settle out in dead spots to build up undesirable concentrations, although this result will probably not occur.

If slurry is added to a main leading from a deep well pump to a distribution system, the fluoride will undoubtedly be dissolved before the water reaches the first customer, if the main delivered to a storage tank or reservoir directly before any customers tapped it. Although no two systems are identical, certain general rules should be given. One approach is to allow the same time for slurry to dissolve in the main that is allowed in the dissolver of a dry feeder. If a 5-minute dissolving time and a 10-fps. flow in the main are assumed, it is found that 3,000 ft. ($10 \times 60 \times 5$) of main will be required to provide the required detention to insure solution.

It seems prudent to recommend that dissolvers be made as efficient as possible. Some small amount of chemical is almost certain to short-circuit to the outlet without dissolving. The number or size of the particles may be so small that they will dissolve completely in the solution line conveying them to the application point. The amount of chemical which short-circuits through a dissolver can be expressed as a proportion of the amount fed and will bear a straight-line relationship to the rate of feed. As dissolving rate approaches design capacity, a larger proportion therefore short-circuits.

Laboratory tests and field experience have indicated that a 5-minute dissolving time is adequate at the above concentrations, which are approximately one-fourth of ultimate solubility. If, in addition, baffling provides a path of longer duration and a quiet zone at the outlet, a negligible amount of undissolved fluoride compound will leave the dissolver, so that all fluoride fed is accounted for in final analysis of the water in the distribution system.

Protection Against Overfeeding

Positive prevention against overfeeding is essential in all installations. In proportioning pump installations, there is little or no possibility of overfeeding when injecting against pressure or elevating to a higher point of treatment. When pumping to a lower level or into a suction line, an air gap or positive break in the solution line should, however, be provided. Figure 5 illustrates a proportioning pump for pumping to a lower level and Fig. 6 shows suction box introducing a solution into a suction line to prevent siphoning. Suction boxes may be used with dry feeders and dissolvers.

In small dry feeders, in which the hopper holds not more than one or two bags of chemical, there is very little or no danger of "flooding" through the feeding mechanism and unloading the hopper, to cause an overfeed. It is only in the larger plants or where tall extension hoppers are used that this danger exists.

Flooding or unloading of chemicals from hopper occurs in only two ways:

1. It can occur when powdered material is dumped into the hopper of an empty feeder, so that it falls a considerable distance and entrains air, causing it to flow on out through the open feeding mechanism from its own velocity. The remedy is to refill before the hopper becomes empty, and while the feeder opening is well plugged by deaerated chemical.

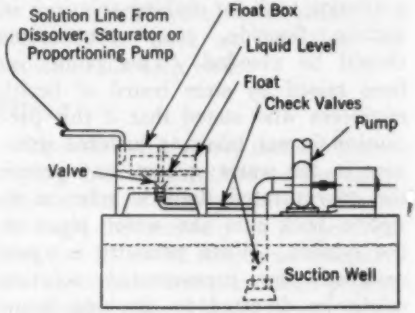

Fig. 6. Suction Box Installation

Use of a suction box is another method of introducing solutions into a line and preventing siphonage.

2. Flooding can occur during feeding if the chemical arches in the hopper. The feeding mechanism empties and then the arch breaks, allowing the material to cave in. In collapsing, the chemical entrains air and becomes fluidized so that it can flow through an open

feeding orifice like a liquid. Although proper agitation will prevent an arch from forming, accidents happen, and the surest preventive is the use of a feeding mechanism that provides a positive stop or lock against the chemical as shown in Fig. 7.

If large hoppers are used above small feeders, to provide storage space, bin gates or valves should be used between the hoppers and feeders so that the feeders can be refilled at correct intervals.

In piping the dilution water to the dissolver of a dry feeder, a saturator or a dilution tank for making solutions of sodium fluoride, cross connections should be avoided. This point has been raised by state board of health engineers who stated that if this precaution is not taken, a lowered pressure in the water system may permit the concentrated fluoride solution to siphon back into the water pipes or the system. When pressure is again resumed the concentrated solution might be diverted to drinking fountains, plumbing fixtures or other uses and endanger health.

In sodium fluoride solution tanks or dry feed dissolvers with mechanical agitators, cross connections are easily prevented. The water supply to the tank is terminated at a point above the highest possible liquid level, so that an air gap exists.

Siphon breaks can be installed in saturators. In dry feeders which utilize water pressure for agitation, a very simple nonmechanical siphon breaker or vacuum breaker can be provided in the piping.

Dissolver or Solution Tank Materials

Solutions of sodium fluoride are corrosive but not extremely active, and stainless steel tanks of proper composition have proved satisfactory. The following materials are also entirely satisfactory: ceramics, rubber-lined, plastic-lined or asphalt- and cypress-lined steel dissolvers, or asphalt-lined (or painted) concrete. Frye at Evanston, Ill.,* states that the pH of the solution leaving the dissolver at that installation is 7.7 if the pH of the finished water is 7.6.

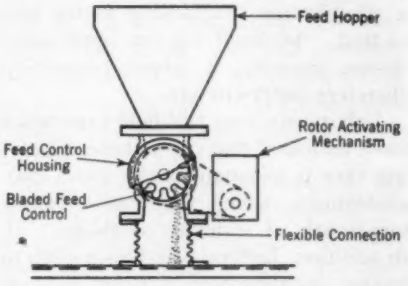

Fig. 7. Dry Feeder With Lock to Prevent Chemical Arch Formation

Bladed feed control provides stop against chemical, preventing flooding.

Solutions of sodium silicofluoride have a much lower pH and are much more corrosive. McCarthy † at Racine, Wis., reports that the pH of the solution leaving the dissolver in that installation is 4.0. The very weak solutions found in the dissolvers under dry feeders do not, however, seem to be as active as originally thought, and type 316 or 317 stainless steel seems to hold up well. The materials of construction listed above for sodium fluoride are also suitable for silicofluoride solutions.

* Communication from Horace R. Frye, Supt. Evanston, Ill., Water Dept.

† Communication from J. J. McCarthy, Director of Labs., Racine, Wis.

Hydrofluosilicic acid should be handled with rubber or plastic materials. Although the acid is saturated with silica and is not extremely active in the concentrated form in which it is shipped, it either absorbs atmospheric moisture at the liquid level or is slightly fuming, so that even glass will be etched above the acid level. The acid should not be diluted and should be used directly from the container in which it is shipped.

Automatic Proportioning

The majority of the automatic proportioning installations will be of the constant rate type, although many of the smaller plants, especially those having well supplies, will require automatic start-stop mechanisms to permit the equipment to function only while the well pumps are in operation. This automatic functioning is easily managed with either dry or solution feeders. A relay in the starting circuit to the deep well pump motor can also start and stop the chemical feeder motor. For dry feeders, a solenoid valve, to open when energized, is required in the water line to the dissolver.

If an eductor is used to pick up the solution from the dissolver and force it to a higher elevation or into a main against pressure, an additional solenoid or motor-operated valve is required for the pressure water line.

In plants where the flow varies hourly or is changed several times a day, as if with well pumps that start in sequence to satisfy varying demand rates, automatic proportioning is essential. This operation requires that the water be metered so that automatic proportioning equipment can control the feeders to change their rate automatically in proportion to flow. Summation instruments are available for totaling the flow if more than one metering point is necessary.

Accuracy of proportioning can easily be determined and recorded if accurate means of checking the amount of chemical fed are provided. It is necessary only to check the volume pumped with the weight of fluoride used to determine whether proportioning has been accurate. Either venturi or propeller type meters may be used to pace the chemical feeders.

In cities supplied by a series of wells that start and stop automatically and do not deliver to a common point, it is necessary to have an individual installation for each well.

Piping

The most satisfactory method of conveying fluoride solutions to the application point is through a rubber hose, although the necessity to support the hose for its entire length to present a neat appearance and prevent air pockets is a disadvantage. Many types of plastic and plastic-lined pipes have been placed on the market recently, all of which are suitable for sodium fluoride, silicofluoride or hydrofluosilicic acid. Since fluoride installations have been in operation for only about five or six years, it is not possible to base recommendations on a longer history of experience. Many plants have also been using ordinary steel pipe for sodium fluoride solutions with satisfactory results, although silicofluoride solutions have been found to destroy steel pipe very rapidly.

Adequate pitch must be provided if gravity flow is employed, and the line should be vented at the dissolver. If the discharge end of the solution piping is below water level, it should be vented

again at the last point at which it makes a vertical drop (Fig. 8).

Eductors

If gravity feeders, such as dry feeders, are used, the solution may be forced to a higher elevation or injected into a line against pressure by eductors. Water to operate the eductors should be at a pressure of at least four times the discharge head, and the eductor should always be kept fully supplied with solution on its suction side. A makeup tank is therefore usually required, or the eductor suction may be taken from the dissolver utilizing a float valve to insure flooding of the outlet. This practice renders water jet agitation inapplicable, making mechanical agitation necessary.

Scaling

If eductors are used for handling fluoride compounds in hard water, some scale formation must be expected. The rate of formation depends somewhat upon the water hardness but primarily upon the volume of fluoride handled.

In a city using Lake Michigan water having about 37 ppm. calcium and 8 ppm. of magnesium hardness, and feeding approximately 10 lb. of sodium fluoride per hour, scale formed in 1¼-in. eductors within one to two weeks. As this condition was entirely unsatisfactory, changes were made in the solution line to permit gravity flow, and no further formation was encountered. It appears that magnesium and calcium fluorides precipitate as a hard scale in zones of intense agitation, whereas they settle out as soft sludges in the absence of speed and agitation. Neither sodium fluoride nor silicofluoride has caused scale formation in gravity flow lines.

In another water supply containing about 40 ppm. calcium and 6 ppm. magnesium, approximately 3 lb. of sodium fluoride per hour was being fed. Scale formed in the eductor in approximately 90 days. Although this condition is not desirable, it was felt that it was preferable to change the eductor, which was arranged between unions for easy removal once every three months, rather than to effect line changes.

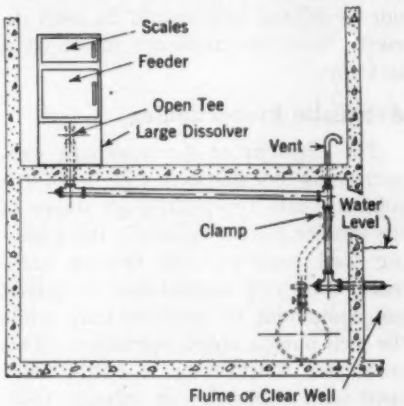

Fig. 8. Gravity Feed Installation

This arrangement provides gravity feed to a flume or clear well. The vent must be provided if the vertical drop extends below the water level. Tee or cross joints should be used instead of ells for the bend in the line after it leaves the large dissolver to facilitate inspection or cleaning of the line. The dotted line attachment shown at the bottom indicates a method of connecting to filter effluent line.

Pumps

If any high-speed pump, either centrifugal or turbine type, is used to move the fluoride solutions when hard water

is used for makeup to maintain capacity operation, clogging and scaling may be expected. Figure 9 illustrates conventional installation of a dry feeder with makeup tank and ejector.

If sodium fluoride solutions are introduced by proportioning pumps through injection nozzles into mains carrying water containing calcium or magnesium, precipitation will occur at the injection point. To prevent this

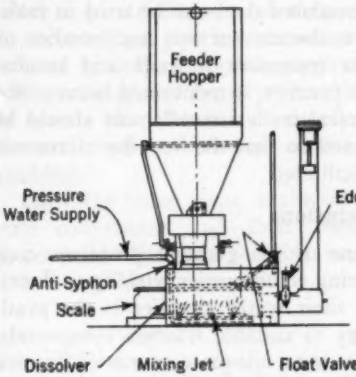

Fig. 9. Dry Feeder Installation With Makeup Tank and Ejector

The water supply from the float valve terminates above water level. Pressure water supply to the eductor should have approximately four times the discharge pressure. The pressure water is supplied for jet agitation.

precipitate from building up and eventually clogging the injection pipe, the end should extend through a corporation cock to facilitate its removal and cleaning.

Prevention of Scaling

Scale formation may be prevented by softening all the water used to convey the sodium fluoride solution or by treating it with a sequestering agent such as Calgon,* Micromet * or Nalco 918.† For eductors, both the dissolving and the eductor water should be softened or treated. In pumping, only the dissolver water need be softened or treated as the excess capacity of the pump over the amount of dissolver water used can be recirculated through the dissolver by a float valve.

The polyphosphate required is a function of water volume as well as chemical characteristics, although the relationship is unknown and can be determined only through the trial and error method. Experience indicates that treatment may range from 7 ppm. to 15 ppm.

Since requirements for Calgon or Micromet are the same, the cost of this method depends on price of the chemical and the application equipment. Calgon and Nalco 918 cost approximately 20¢ per lb. and require a motor-driven feeder. Micromet costs $1.25 per lb. but can be fed by a pressure pot type of feeder which is nonmechanical and very inexpensive, costing approximately $50.

In making up solutions of sodium fluoride for proportioning pumps, polyphosphate may be added to the dissolving water to prevent precipitation of calcium and magnesium fluoride sludge. This practice will also prevent calcium buildup at the injection nozzle discharge orifice where the solution is introduced into a main under pressure. One to two ounces (5–10 times the hardness in ppm. as $CaCO_3$) of polyphosphate per 100 grains of hardness in the dissolving tank may be required to

* A product of the Calgon Corp., Pittsburgh, Pa.

† A product of National Aluminate Corp., Chicago, Ill.

sequester the calcium and magnesium completely.

A possible objection to this use of polyphosphates is that they may cause a slight increase of the apparent fluoride content, as indicated by certain laboratory results. The amount of polyphosphate so added should be quite small in comparison with the normal polyphosphate treatment of municipal water supplies.

Sodium silicofluoride solutions may be handled in eductors without clogging by calcium or magnesium fluoride deposits as calcium and magnesium do not readily precipitate at low pH values. Silicofluoride solution has been handled by an eductor for sixteen months with no difficulty at Oshkosh, Wis.* A very small installation in Wisconsin has used a $\frac{3}{8}$-in. bronze eductor for silicofluorides for approximately one year without any trouble.

Dosage Points

The conventional application point for fluoride solutions is in filter effluent lines or in the clear well. At small plants using well supplies, the solution is injected into the discharge from the deep well pump.

The water utility at Racine, Wis., using Lake Michigan water, adds silicofluoride to the filter influent and the fluoride loss is approximately equal to the 0.1 ppm. fluoride content of the raw water.

Fluoride should not be added with or before coagulants or with softening chemicals. Feeding sodium fluoride solution ahead of lime softening has on occasion caused the loss of approximately one-fourth of the fluoride. Aluminum sulfate has even been used to effect fluoride removal.

* Private communication from H. J. Schneider, Filtration Supt. and Chemist, Oshkosh, Wis.

Records

Most state boards of health insist on periodic reports on the amounts of fluoride and chlorine used, and some request reports on consumption of all chemicals. The keeping of accurate records also results in better equipment and plant maintenance and more careful operation of equipment. The accumulated data can be used in making authentic surveys and studies of water treatment practice and results. This practice is mentioned because the chemical feeder installations should be planned so that the keeping of records is facilitated.

Conclusions

One of the greatest problems confronting communities wishing to fluoridate their water supplies is the availability of suitable fluoride compounds. There is an adequate source of fluoride as a by-product of fertilizer manufacture, although a very considerable expenditure will be necessary to supply fluorides by this process, as rubber-lined equipment is required to produce either fluosilicic acid or silicofluoride. A single large superphosphate fertilizer plant may have a potential to produce 3,000–4,000 tons of 22 per cent hydrofluosilicic acid per year. With the possibilities that interest in the fluoridation program may decrease sharply, and that some method of introducing fluorine into the diet other than through water may evolve, the reluctance to make the investment is understandable. Manufacture of the acid requires somewhat less equipment and skill than manufacture of the sodium silicofluoride. The manufacturer's problem is

disposing of acid that has been produced—he must ship it, sell it, get rid of it. The encouragement of 5-year contracts for acid at prices competitive with current prices for silicofluoride (5–6¢ per lb.) on a fluorine content basis would probably bring some recovery plants into existence.

The construction of sodium silicofluoride plants has some appeal because this material can be stored easily and inexpensively. Salt (sodium chloride) is plentiful, and a shortage such as occurred last year in soda ash, which is used in sodium fluoride production, will probably not be experienced. It is certain that the law of supply and demand will eventually solve this problem.

Only the three most available fluoride compounds and their handling have been discussed in this review. Almost all the clinical evidence supporting the benefits of fluoridation has been based on the use of sodium fluoride, although other compounds may later be found to be equally beneficial. Selection of an installation that is flexible enough to permit a choice of fluoride compounds may therefore have future advantages and thus affect one's viewpoint.

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APPENDIX

Basic Information on Fluorine Chemicals

Sodium Silicofluoride (Fluosilicate) (Na_2SiF_6)

Characteristics. The density of this compound is approximately 72 lb. per cu. ft. It is white (unless tinted nile blue for identification), and is a free-flowing, nonhygroscopic, crystalline powder which contains no water of crystallization. Containers carry a label to warn against hazardous handling. The pH value of a fluosilicate solution depends upon several factors. A 1 per cent solution of 98 per cent NaF has a pH of 6.5, and a 4 per cent solution of 95 per cent NaF has a pH of 7.6.

Packing. Lots of 100 lb., net, are packed in moisture-proof paper bags that are approximately 17 × 25 × 6½ in., while 125-lb. lots are provided in fiber drums, and 425-lb. lots (499 lb., gross) are available in paper-lined slack barrels or fiber drums.

Shipping regulations. Paper bags may be used only for carload lots or truck shipments. There is an extra charge for barrel or drum shipments of approximately $.20 to $.40 per cwt. Bulk shipment is not currently permitted by ICC regulations.

A minimum carload quantity depends on shipping point and destination but is usually 30,000 lb. Maximum carloads may be more than 80,000 lb. Truckloads are ordinarily approximately 20,000 lb.

Sodium Fluoride (NaF)

Characteristics. This material has a density of 65 lb. per cu.ft. It is white (unless tinted nile blue for identification), odorless, nonhygroscopic and crystalline,

and is available in either powdered or crystal form. Containers carry a warning label.

Packing. It is packed in the same types of containers, for corresponding lot sizes, as silicofluoride, although the large drums usually hold 375 lb., net.

Shipping regulations. Provisions for shipment are the same as those for silicofluoride.

Hydrofluosilicic Acid (H_2SiF_6)

Characteristics. Commercial grades vary in strength from 22 to 30 per cent. The weight is 10.5 lb. per gal. It is a transparent, colorless, highly corrosive, slightly fuming liquid and, although not as dangerous to handle as sulfuric, hydrochloric or nitric acids, as it does not act as rapidly on the skin, caution should be exercised when handling it.

Packing. This compound is available in the following shipping containers: 10-gal. carboys, 100-lb. wooden kegs, 125-lb. and 420–550-lb. rubber-lined steel drums and 90,000-lb., net, rubber-lined tank cars. Deposits, such as $30 for a 125-lb. rubber-lined drum, are required on returnable containers.*

Shipping regulations. As this material is a corrosive liquid, a white label is required. Samples cannot be sent through the mails.

* Information from Davison Chemical Corp., Baltimore, Md.

Decomposition. Hydrofluosilicic acid is generally believed to exist only in solution, and not in the vapor phase. Upon vaporizing, it decomposes into hydrofluoric acid (2HF) and silicon tetrafluoride (SiF_4). This equilibrium exists at the surface of strong solutions. The small concentration of hydrofluoric acid may slowly attack the glass above the solution level. It is therefore ordinarily shipped in rubber-lined containers.

Sample Label

A sample warning label for a sodium fluoride container is shown below.

95 Per Cent Sodium Fluoride Light

WARNING

Poisonous if taken internally.
Avoid breathing dust.
Keep away from food.
Flush spillage to sewer with water.

POISON

Call a physician immediately.
Antidote: Give a tablespoonful of salt in a glass of warm water and repeat until vomit fluid is clear. Precede by lime water or 1 per cent calcium chloride solution if available.
Give strong tea or coffee or teaspoonful aromatic spirits of ammonia in water.

Copper With Ammonia and Chlorine in Finished Water

By Marsden C. Smith

A paper presented on Apr. 30, 1951, at the Annual Conference, Miami, by Marsden C. Smith, Chief Water and Research Engr., Dept. of Public Utilities, Richmond, Va.

THE beneficial effect of copper on the potability of water has been known since long before Christ. About 2000 B.C. it was recorded (1): "It is good to keep water in copper vessels, to expose it to sunlight and filter through charcoal." Exposure to sunlight probably failed to stimulate the growth of algae, and so cause taste and odor complaints, because of the efficiency of copper in limiting their growth. In India and other middle eastern countries, the use of copper containers and the immersion of hot metallic copper into a contaminated water are still used as effective means of bacteriological purification.

The presence of copper in drinking water has unfortunately been considered dangerous, or at least undesirable, by many sanitary engineers, and the benefits of its use in potable water supplies have therefore been seriously limited. For example, at Richmond, Va., it was deemed unwise to use copper for any purpose or any treatment stage that would result in its being present in the delivered water. The only benefit available, therefore, was the control of algae in the gravity subsidence basins because subsequent coagulation and filtration removed all copper before the water was delivered to any consumer.

Depreciation of Finished Water Quality

Not enough attention has been directed to delivery of water to the consumer in the same excellent state as when leaving the well operated, modern purification plant. The consumer, however, can judge the potability of a public water supply only by its quality at the point of use—not by the purity records of the plant.

At Richmond, all of the finished water must pass through the postfiltration aerator basins and a 52-mil.gal. uncovered storage reservoir before reaching the distribution system. These containers create ideal conditions for the growth of undesirable algae with such disastrous effects that they largely nullify the purification processes, however successful they may be.

Chloramines as Algicides

The seriousness of algal growth in the finished water and throughout the distribution system led many years ago to the introduction of postchlorine and ammonia for the formation of chloramines in the finished water. This treatment appreciably lessened the problems created by the algae growths, but the improvement was not sufficient to relieve the intolerable conditions still

existing in the aerator basins, the open reservoir and the distribution system.

Intermittent Copper Sulfate

Virtual ruination of good water necessitated use of copper for algal control, but fear of copper poisoning led to the adoption of a precaution that was later considered unnecessary—even silly. Treatment of only one section of the reservoir—previously disconnected from the system—was practiced at a time. Copper sulfate was sprinkled around the edge of the reservoir, trusting to luck to secure adequate distribution throughout the water. When the treated area was again placed in service, the dead algae entered the distribution system clogging meters almost as quickly as they could be changed, in addition to creating taste problems.

Physiological Effects of Copper

Necessity forced a more careful examination of the danger to consumers from water containing limited amounts of copper. Contrary to prevailing opinions, no supportable reason for prohibiting all copper could be found.

Copper was instead found to have been used medicinally in doses as great as 20 mg. daily as sulfate, with no apparent harmful effects. Cow's milk, the universally accepted food standard, contains 0.5 ppm. of copper, and it has been definitely shown that more than 1.5 ppm. must be present before the taste of copper is detectable. Copper stains on white plumbing fixtures rarely occur when the copper content is less than 30 ppm. The human body actually requires at least 2 mg. of copper a day, and consequently, a normal person drinking water with 0.5 ppm. or less is probably benefited—certainly not harmed—by this ingestion of copper.

On the basis of these findings, an appeal was made for the first time to the state department of health to approve the use of copper in finished water in quantities sufficient to cause approximately 0.2 ppm. to be present after the water had passed through the basins and reservoir and into the distribution system.

After thorough consideration by the department, approval was given, and copper sulfate was added continuously to the water immediately after filtration. This operation was effected with no change in the chlorine or ammonia quantities previously used. The copper sulfate was merely added at essentially the same point. The three chemicals are immediately and thoroughly mixed by passing through the aerator centrifugal pumps and spray nozzles. Aeration increases the oxygen content by entraining air. It also raises the pH of the water by releasing carbon dioxide. As rapidly as the water is displaced in the aerator basins, lime is added to the effluent to elevate the pH further to an average of 8.8. Further mixing is then effected by passing the water through the centrifugal pumps that elevate it to the open storage reservoirs through which it must pass before entering the distribution system.

Fish Mortality

The first continuous use of copper almost immediately resulted in the death of all fish in aquariums near the outlet of the reservoir. This condition was serious enough to require reducing residual copper to trace quantities. This reduction was continued until fall, after which the use of copper was discontinued until the following spring.

When copper was again added, even with as little as 0.1 ppm. in the effluent, the complaints of fish deaths soon in-

creased to the same level and over a wider area than had occurred during the previous summer. This situation led to the development of a simple cation exchange filter which effectively removed the copper that was believed to be the cause of the complaints. It was unexpectedly found that, when the cation exchanger in the filters became saturated with copper, the copper content of the water in the aquariums rose to that existing in the distribution system, but the fish continued to live. This improvement indicated that the cause of fish mortality was not entirely the toxic effects of the copper but, at least partially mechanical factors such as the clogging of the gills with dead organisms previously existing in the distribution system. It was then apparent that as soon as the existing algae could be effectively eliminated from the system, the mechanical straining afforded by the filters would no longer be required. This conclusion proved correct, and the filters are no longer used. The fish are living happily in water containing an average of 0.1 ppm. of copper throughout the entire distribution system.

The welfare of fish may seem unimportant to those who are not initiated; but at a cost of several hundred dollars a pair for rare specimens, fish life can become of economic importance. To this must be added the fear generated in the mind of the public, which does not realize that there is a great difference between a fish's breathing water and a human's drinking it.

Results

The benefits derived from the use of copper sulfate with ammonia and chlorine in the finished water have been remarkable. The masses of algae that thrived in the reservoir have now been eliminated completely. The cleaning effect on the mains, the reduction of bad water complaints and the freedom from stopped and clogged meters are indeed a handsome return on the small cost of this method of copper treatment.

In this treatment, however, the quantity of copper required for control is much less than would be required if it were used alone, without the ammonia and chlorine. The toxic effect of ammonia and chlorine without the copper is not nearly sufficient for proper control of algae. What then is the reason for the effectiveness of the triune: copper, ammonia and chlorine? Is the greater efficiency of copper sulfate as an algicide when applied with chlorine and ammonia due to physical or to chemical factors? By physical factors is meant the constant maintenance of a definite residual rather than intermittent application in much higher concentrations. By chemical factors is meant the possible combination of copper with the chloramines to form a compound of greater algicidal potency than that of either the copper or the chloramines alone.

Chemistry

In the dilutions used, it has been quite difficult to determine whether any chemical combination occurs between the chloramines and the copper sulfate. Prolonged studies in well equipped general chemical laboratories have yielded no definite evidence. There are, however, strong indications that there is at least a limited or partial chemical combination of these chemicals into a new compound of undetermined composition.

A most extensive report of this chemical treatment in water practice was made by C. H. Harold (2). Although water works people in Rich-

mond have not fully concurred with all his statements, the studies merit the highest praise. He states that "It appeared that a combination of chloramine with copper had been produced." He also reports that: "The most toxic results appear with concentrations of components approximating to a compound such as chlorine and cuprammonium, which for convenience may be termed cuprichloramine."

Dr. Charles White * has written:

> Your thesis that copper will form a chloramine complex is perfectly justifiable from a theoretical standpoint. However, I do not know of anyone who has made this particular compound.
>
> My calculations would indicate that in the Richmond water supply you are adding a little over 4 moles of ammonia for each mole of copper. This would be sufficient to form complexes of the type $(Cu(NH_3)_4^{++}$, or $(Cu(NH_2Cl)_4^{++}$. The high pH that is attained with the use of lime would keep the ammonia as aqueous ammonia and retard the formation of ammonium chloride. This would favor the formation of the complex ions of copper indicated above. These complexes will keep the copper in solution even at a high pH. I am sure that the statement of the authority quoted was intended for pure water solutions and not for one containing ammonia or chloramine.
>
> These complexes with copper should retain the ammonia or chloramine in the system much longer than when copper is added. The copper should not be replaced by the iron of the pipes as it may be when in the form of copper sulfate.

It was also found (1) that the most efficient results are obtained by the use of copper sulfate as the source of copper and anhydrous ammonia for the formation of the cuprichloramine. In the laboratory the most efficient ratio was 0.3 ppm. of copper, 0.25 of chlorine and 0.15 of ammonia. To compensate for the loss of ammonia, in practice it appears that 0.3 ppm. of each chemical was used.

In Richmond, a slightly different approach is taken. The residual chlorine entering the distribution system is maintained at that value previously used and believed to be the minimum for maximum bacteriological safety. The copper is held to a minimum for effective algae control because the copper is regarded only as an algicide. The annual average (with a rather wide seasonal variation) of the quantities used for these purposes is 0.25 ppm. of copper, 1.74 of chlorine and 0.30 of ammonia.

Although there has been no success in determining the chemistry of the "cuprichloramines," other observed facts support Harold's theory (2) that there is some degree of combination between the copper and the chloramines.

One eminent authority has stated informally: "It should be possible to maintain a residual of 0.1 ppm. of copper in any water by the use of copper sulfate up to a pH of about 7.7, above which theoretically there would be almost complete precipitation of the material." This theory is supported by laboratory analyses of water containing no ammonia or chlorine. The data in Table 1 seems not to support the theory if copper and chloramines are present, unless time is assumed to be unlimited.

Information in Table 1 is based upon several single samples of water taken simultaneously and kept covered but not sealed. From these samples, por-

* Private communication from Charles White, Prof. of Inorganic Chem., Univ. of Maryland, College Park, Md.

tions for analysis were drawn on the dates shown. For twenty days, the pH of one group remained at an average in excess of pH 7.7 and yet the loss in copper residual was only 0.05 ppm. The copper is in the presence of chloramines, which may account for its abnormal solubility. The experiments from which the data of Table 1 were derived were designed to parallel plant and system conditions. A rapid reduction in pH naturally occurred much more rapidly than in the basins because of the relatively minute quantities taken for the samples compared with the total plant effluent.

To determine the effects of maintaining the pH by frequent additions of fresh lime solutions, the data in Tables 2 and 3 were collected. With a small initial quantity of copper that is more than the amount sufficient for algae control when used as "cuprichloramine," the residual after 192 hours is essentially the same for the entire range of pH used. If the initial quantity of copper is many times greater than that used in plant operation, however, a greater reduction in the copper residuals occurs. The greater loss in residuals at pH 7.9 and 8.5 than at values either above or below these may be significant.

It is possible that the smaller residual copper loss which occurs when a smaller initial quantity of copper is in the water, indicates that there is a limited combination of the copper and chloramines into a more stable compound. Results of studies already completed have not been sufficiently conclusive to provide adequate proof of the correctness of this hypothesis.

In all of the tests reported in Tables 1, 2 and 3, the source of the copper was the commercial grade of crystal sulfate. Parallel tests were made with copper from other sources—one a physical mixture of approximately two parts of sodium citrate mixed with one part of finely ground copper sulfate. In the laboratory, no difference was noted in the effectiveness of this compound under simulated plant condi-

TABLE 1

Copper Loss

Date	Plant Filtered Water				Plant Aerated Water			
	No Lime		Lime Added		No Lime		Lime Added	
	pH	Cu *ppm.*	pH	Cu *ppm.*	pH	Cu *ppm.*	pH	Cu *ppm.*
12/1/50	5.95	0.50	8.90	0.50	6.20	0.50	9.50	0.50
12/4/50	6.95	0.50	8.00	0.50	7.15	0.50	8.40	0.50
12/6/50	7.40	0.47	8.00	0.45	7.25	0.48	7.97	0.45
12/11/50	7.20	0.45	7.65	0.45	7.30	0.48	7.75	0.45
12/15/50	7.25	0.45	7.65	0.45	7.32	0.48	7.80	0.45
12/20/50	7.45	0.45	7.60	0.43	7.45	0.48	7.80	0.45
12/27/50	7.40	0.45	7.40	0.43	7.35	0.48	7.55	0.45
1/3/51	7.20	0.45	7.10	0.43	7.37	0.48	7.57	0.45
1/9/51	7.25	0.45	7.20	0.43	7.40	0.48	7.67	0.45

TABLE 2

Copper Loss in Plant Filtered Water—Lime Added to Control pH

Hours	pH	Cu ppm.	pH	Cu ppm.	pH	Cu ppm.	pH	Cu ppm.	pH	Cu ppm.	pH	Cu ppm.
0	7.0	0.20	7.70	0.20	7.90	0.20	8.50	0.20	8.5	0.20	9.5	0.2
24	6.90	0.15	7.30	0.20	7.20	0.20	7.10	0.20	8.4	0.20	7.8	0.2
24	*	—	7.60	—	7.75	—	8.50	—	*	—	9.5	—
96	7.05	0.15	6.80	0.20	7.05	0.20	8.30	0.15	7.8	0.20	7.2	0.2
96	*	—	7.50	—	7.90	—	*	—	*	—	9.5	—
120	6.80	0.10	6.85	0.15	7.25	0.15	8.75	0.10	7.7	0.20	8.8	0.10
120	7.0	—	7.50	—	7.80	—	*	—	*	—	9.5	—
144	6.85	0.10	7.0	0.15	7.20	0.15	7.60	0.10	7.8	0.15	9.2	0.10
144	*	—	7.45	—	7.85	—	8.60	—	*	—	9.4	—
192	6.45	0.10	6.90	0.15	7.0	0.10	7.15	0.10	7.3	0.15	8.9	0.10

* pH not corrected.

tions. In actual plant operations, however, it appears that for the same copper residual in the distribution system, only one-half as much of the mixture by weight is required as of copper sulfate. It may therefore be said that it now appears that if chloramines are present in Richmond water, no practical advantage can be secured with copper from any source other than the commercial grade of the crystal sulfate currently available.

Feeding Copper

In plant operation, the copper is fed through Omega motor driven flat disc feeders * with stainless steel hopper, lining and solution tank.

The sulfate is received in 100-lb. bags, and the feeder hoppers are manually filled as required. The small quantity used makes unnecessary the

* A product of Omega Machine Co., Providence, R.I.

TABLE 3

Copper Loss in Plant Filtered Water Using Larger Copper Dosages—Lime Added to Control pH

Hours	pH	Cu ppm.	pH	Cu ppm.	pH	Cu ppm.	pH	Cu ppm.	pH	Cu ppm.	pH	Cu ppm.
0	6.8	0.7	7.60	0.70	7.90	0.70	8.50	0.70	8.50	0.7	9.40	0.7
24	7.6	0.6	7.55	0.70	7.75	0.40	8.40	0.40	8.30	0.7	9.40	0.6
24	7.2	0.6	*	0.70	*	0.40	*	0.40	*	0.7	*	0.6
96	7.1	0.6	7.10	0.55	7.10	0.30	7.25	0.30	7.45	0.7	9.15	0.4
96	*	0.6	7.50	0.55	7.80	0.30	8.50	0.30	*	0.7	9.60	0.4
120	7.1	0.5	7.10	0.40	7.40	0.25	7.60	0.15	7.45	0.6	9.15	0.4
120	*	0.5	7.50	0.40	7.80	0.25	8.50	0.15	*	0.6	9.50	0.4
144	7.2	0.4	7.0	0.40	7.40	0.20	7.50	0.10	7.30	0.5	9.15	0.3
144	*	—	7.55	—	7.80	—	8.40	—	*	—	9.55	—
192	6.8	0.4	7.15	0.40	7.10	0.20	7.20	0.15	7.0	0.5	9.20	0.2

* pH not corrected.

more efficient but expensive mechanical handling.

Conclusion

The effectiveness of copper and ammonia and chlorine in the control of algae in finished water has been found to be much greater when used in combination than when used separately. The cost of copper required for complete algae control in the finished water basins and reservoir is negligible, not more than 16¢ per mil.gal. The handling, storage and feeding of all copper compounds used are very simple. The desired level of residual copper is easily maintained, even in water of high pH, when applied with proper relative quantities of ammonia and chlorine.

References

1. Baker, M. N. *The Quest for Pure Water.* Am. Water Works Assn., New York (1948), p. 1.
2. London Metropolitan Water Board. *29th Annual Report for the Year Ending December 31, 1934.* London (1935), pp. 61–80.

Editor's Note: The value of copper salts as an end treatment material deserves more attention than it has received. Harold's London work on cuprichloramine was confirmed by Calvert at Indianapolis. In 1945, Amsbary published (Jour. A.W.W.A., Vol. 37, p. 294) records of his work at Champaign, where distribution system aftergrowths were being controlled by treatment of the filter effluent with copper sulfate. Amsbary's work was of the same nature as Smith's in Richmond.

The account of the Richmond work is reminiscent of the discovery in the winter of 1907–08, that the operations of the slow sand filters at Indianapolis, then without pretreatment of the raw water before it entered the filters, were not satisfactory. Since the original study by Moore and Kellerman, using copper sulfate as an algicide, was known, it was decided to use it as a bactericide for treatment of the filtered water. The procedure used would not compare favorably with present day methods, but it did reduce very substantially the bacterial content of the filtered water. Later in 1908, chloride of lime was used by Johnson at the Chicago stockyards water treatment plant, and early in 1909, chlorination was started in Indianapolis. Now Smith confirms the value of copper salts as an end treatment for water.

Well Construction and Operation

By Paul Schweitzer

A paper presented on May 2, 1951, at the Annual Conference, Miami, by Paul Schweitzer, Pres., Layne-Atlantic Co., Norfolk, Va.

SEVERAL Oriental wells known to have been constructed more than 500 years ago are still in daily service today. These ancient wells were dug by hand, without benefit of modern equipment and materials, to astonishing depths of more than 2,000 ft. No steel or wrought iron for well casing existed when they were sunk, and bronze, stainless steel, brass or Monel metal well screen had not even been heard of. Crude brick and bamboo were ingeniously employed to serve as well casing.

Many years—sometimes two generations—were required to complete some of these fantastic wells. Many lives were lost in cave-ins and from suffocation, yet these people considered the wells not only safe, but economically sound investments. The water secured was ample to supply the primitive needs of the time.

All kinds of modern equipment are now available with which to construct a well of almost any diameter, depth and type. Also at hand is a multitude of materials from which to select the proper casing, screens, pits and appurtenances. Despite these happy conditions, many problems of safe yield remain to be solved. The ever-increasing demand by industry, agriculture and municipalities for more and more ground water makes these problems a continuous consideration. If nature has not provided all the conditions necessary for the successful development of a ground water supply of the magnitude required, well construction is of little or no value. There are many areas, however, in which all the natural conditions for successful development of substantial ground water supplies do exist. The geologists and scientists may predetermine these sites, yet certain natural physical barriers tend to make it economically impractical, if not unsafe, to attempt a ground water development of any great size.

Techniques in well construction have been improving continuously, but the limitations of time and space do not permit a discussion of them here. Instead, large industrial ground water development in northern Florida will be discussed.

Sample Problem

A series of fourteen wells, each of 20-in. diameter, and more than 1,000 ft. deep, having a combined yield of approximately 60 mgd., secure their water from the very prolific Ocala limestone.

Continuous, successful pumping from this source for more than ten years indicates that natural subsurface conditions are favorable. The water is there; recharge is ample; and general conditions can therefore be considered safe.

Although all the wells in this area are of the same diameter and approxi-

mately the same depth, they do not all produce the same amount of water. Apparently the bore holes in the aquifers do not intercept solution channels of uniform number and character. The production of each well varies directly with the specific yield in gallons per minute per foot of drawdown.

Well No. 4, for example, was constructed with 550 ft. of 20-in. casing set and cemented through the Hawthorne and into the Ocala limestone. A 20-in. hole was then drilled 1,050 ft. below the surface. After the water level had stabilized, this well had a net yield of 19.4 gpm. per ft. of drawdown. In actual operation, the pumping level was established at 100 ft. below ground surface, which made a net yield of 2.8 mgd.

Well No. 7 in the same area, substantially the same in depth and construction details, leveled off with a specific yield of 15.3 gpm. per ft. of drawdown; a production of 2.2 mgd., with a pumping level 100 ft. below the surface.

Well No. 2, similar to No. 4 and 7, had a much better record. After stabilization, the specific yield was 24.3 gpm. per ft. of drawdown, a production of 3.56 mgd.

After producing for ten years or more, additional water was required and had to be secured. It was apparent that the production obtained represented safe yields, but probably not the maximum safe yields that could be obtained, if more solution channels in the aquifer could be intercepted.

Possible Solutions

This additional water might be obtained by one of several methods:

1. Drilling more wells and thereby reducing the distance between wells. If this course had been followed, it would have required a considerable amount of additional casing, more pumps, motors and accessory equipment.

2. Extending the well field, which would have involved not only additional casing, pumps and motors, but acquiring more property, lengthening pipelines and power lines.

3. Devising some method of intercepting more solution channels to feed into the existing wells. If this method could be followed with moderate expense, the yield of each well would be increased safely.

The last method seemed most practical, and No. 4 well was selected for experiment.

A special whipstock was designed to insert and secure in the 20-in. casing just above the point of contact with the water-bearing formation. This whipstock made it possible to drill an offset hole of approximately 10-in. diameter just below the casing. The angle of the offset hole was established at 3 degrees 30 minutes from vertical, which was the maximum angle considered safe for operation with available equipment.

The offset hole was continued to a depth of 1,055 ft. From the angle of attack of the bit, it was calculated that the bottom of the offset hole was approximately 20 ft. from the bottom of the original 20-in. boring.

Two additional 10-in. offset holes were then drilled at 120 deg. spacing around the original 20-in. bore. When completed there was one 20-in. hole and three 10-in. holes all connected to a common 20-in. casing.

On testing, No. 4 well then had a specific yield of 30.5 gpm. per ft. of drawdown, or 4.4 mgd. The net specific yield increase was 58 per cent. These results fully substantiated the

theory that yields could safely and economically be increased if more solution channels could be connected to a well.

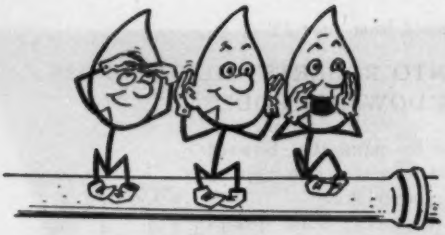
Inclusion of Other Wells

A similar program of offset drilling was then initiated on No. 7 well, in which four 10-in. offset holes were equally spaced around the 20-in. bore. No. 7 was selected because its specific yield was only 15.3 gpm. per ft. of drawdown, giving a production of 2.2 mgd.—the poorest in the area. On completion of this operation, the specific yield of No. 7 was 31.9 gpm. per foot of drawdown or 4.6 mgd. The net increase was 108 per cent.

Well No. 2, a similarly constructed unit, but a much better producer, with an original net yield of 24.3 gpm. per foot of drawdown and net production of 3.5 mgd., was then offset drilled with three 10-in. holes with very gratifying results. On completion the specific yield was increased 57 per cent to 38.2 gpm. per foot of drawdown or a production of 5.5 mgd.

The net combined production of these three wells have been increased from 8.5 mgd. to 14.5—net daily gain of 6 mil.gal. or 70 per cent without lowering the pumping level. More solution channels had simply been opened up to the well casing.

Not all wells, of course, can be safely increased in capacity to this extent, but if the necessary natural factors exist, ingenuity and resourcefulness can very often safely and economically increase specific yields for the ever-increasing needs of municipalities, industry and agriculture.



Percolation and Runoff

It's fire frighting time again. With Fire Prevention Week due October 7–13, the National Fire Protection Association is busy statisticizing our conflagrant past and advising us how we may avoid an even more fiery future. The fact that this gives us fright ought to make us all the more eager to hop aboard the ban wagon to help halt those needless fires that now break out somewhere in the country every twenty seconds. What more enlightened self-interest, anyway, than thus to sponsor water conservation?

Quick coverage of the nation's water problems gives us the last, if shortest, word on the where, how and why of worries over water supply. In the August 13 issue of this newcomer among news weeklies, water rated a cover streamer and a three-page feature article—comparable with at last a special supplement in something less hurried than *Quick*. "Quick" is really the word for the coverage, too, inasmuch as three well-illustrated 4 × 6-in. pages transport us from the hydrologic cycle into the realm of atomic pumps lifting distilled sea water inland. Certainly not *dead!*

Our diary of dowse continues full. First, following his July *Harper's* article, Tom Riddick was called upon to elucidate his enmity to Mutual Broadcasting System listeners when Bill Slater interviewed him on the "Luncheon at Sardi's" program of Friday the 13th, of July. Then, three days later, *Time,* too, took Tom at his word, disappointing us only by failing to call the art "Riddickulous."

With August, however, came front-page proof of dowsing—first from Orchard Park, N.Y., where a service station owner in need of a new well dowsed in a gusher that took the town's water main crew some hours to repair and, then, from Bristol, R.I., where a Philadelphia-dowsed well (see August P&R, p. 2) brought real moisture at the promised 32 feet, though still no "supply" at the 70-ft. abandonment depth.

But the tale of the month was one by a wag from the big city, whose shaggy doggerel is reprinted below, by permission, from *The New Yorker* magazine of July 14:

(*Continued on page 2*)

(Continued from page 1)

ON FIRST LOOKING INTO ROBERTS' "HENRY GROSS AND HIS DOWSING ROD"

We had a dog and his name was Bowser,
Wasn't much good as a water dowser.
Too busy dowsing other things
To fool around with underground springs.
He knew if a rabbit was hid in a hole
And where in a molehill crept the mole.
No one could dowse a cat or a mouse or
A grouse or a quail as well as Bowser.
But the reason Bowser was widely known
Was the confident way he could dowse a bone.
He would go and find him a hazel sprig,
Or else he would bite off a willow twig,
Then, holding one end of the stick in his teeth
And letting the other hang down underneath,
He would ask the rod in an undertone,
Where in the world did I bury that bone?
Was it to the north of here?
And the rod would say No.
To the south?
The rod said No.
The east?
Rod said No.
West?
Yes.
Was it 1½ rods to the west?
The rod said No.
1⅝ rods?
Rod said No.
1¾ rods?
Said No.
1⅞?
Yep.
Was it about 2.091 inches down?
Rod said Not quite.
2.090 inches?
Maybe.
2.089?
Right.
His rod was always as right as rain!
Though he never discovered a water vein,
He could locate a bone and dig it up
From the time he had been a divining pup
Till the time when his candle was burning dim
And finally Bowser dowsed the glim.

—Robert A. Kissack Jr.

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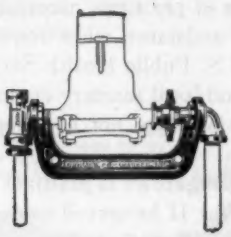
(Continued on page 4)

a Ford Yoke

for EVERY SETTING



Ford Yokes are made in styles to meet every meter setting condition—indoors or out. Regardless of location, the Ford Yoke makes settings easier, removes pipe strains, saves labor and keeps meter connections permanently aligned for fast changes. Roughly, Ford Yokes are made in three styles:

1. Riser Yokes, to use where the meter must be raised above the service line.
2. Angle Yokes, to satisfy a vertical inlet, horizontal outlet condition.
3. Straight Line Yokes, for setting meters in a horizontal line without raising the level of the meter.

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FOR BETTER WATER SERVICES

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(*Continued from page 2*)

Pipeline to the Clouds is the name of a new General Electric Co. film which features water supply and purposes to help water works men sell their communities on the importance of water supply projects. Anyone who saw GE's earlier anti-pollution movie, "Clean Waters," will have an idea of how effective a tool this new film can be. And to round out its "More Power to America" community-action program GE has prepared a 36-page manual telling the story of "Good Water and Plenty of It!" You may borrow the film at any GE sales office and write for a copy of the manual to Adv. & Sales Promotion Dept., Schenectady 5, N.Y.

A Water Resources Division has been created by the National Production Authority with Harvey S. Howe as director, in order that the needs of the defense program—as well as civilian requirements—will be met. Established to meet the demand of water and sewage treatment associations —including A.W.W.A.—for an effective claimant agency for these utilities, the NPA program will set up a small control group of technicians to plan for national needs in the fields of industrial, public and domestic water supply, and sewage and waste disposal. Their function will be to distribute allotments of materials, supplies and equipment required for defense and essential civilian activities; to recommend the issuance of priorities necessary to carry out the programs; and to offer individual assistance when required. Existing staffs of the U.S. Geological Survey, U.S. Public Health Service, Housing and Home Finance Agency, and state and local sanitary engineers will be drawn upon for assistance, as the division does not contemplate organizing a field staff of its own.

On loan to NPA from the Lock Joint Pipe Co., Howe is assistant vice president of that organization. During World War II he served as deputy director of the Water Div. in the War Production Board's Office of War Utilities. Before joining Lock Joint Pipe Co. he had been with the Scranton-Springbrook Water Service Co. of Pennsylvania, the Federal Water Service Corp. of New York, and the Pitometer Co., also of New York.

(*Continued on page 6*)

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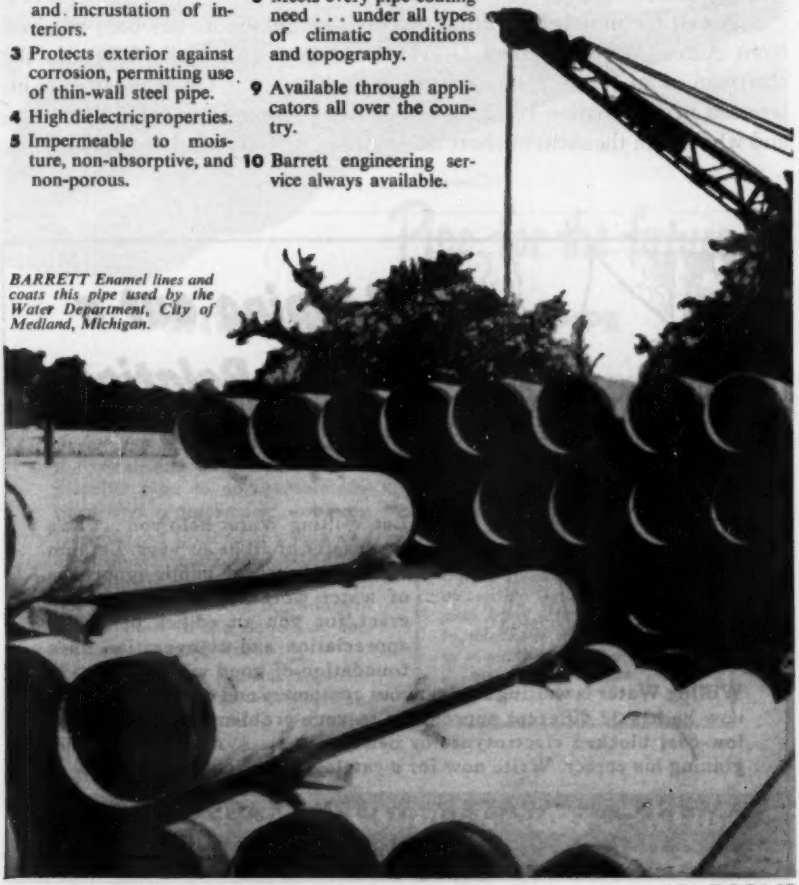


BARRETT Enamel lines and coats this pipe used by the Water Department, City of Medland, Michigan.

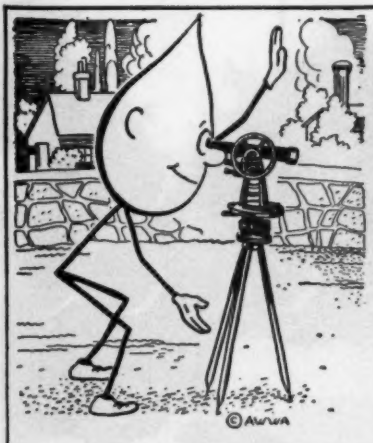
* Reg. U. S. Pat. Off.

(Continued from page 4)

The microfilm edition of the 1950 JOURNAL is now ready and is available to qualified subscribers to the regular printed edition of the JOURNAL from University Microfilms, Ann Arbor, Mich., at a cost of $8.00. It is felt that obtaining the microfilm copy after the paper edition has undergone its first months of maximum use permits discarding the latter and substituting the microfilm for occasional reference, with consequent savings in space and protection against lost copies, missing pages and other inconveniences. The adoption of microfilm files is of course most practicable when used for a number of publications. A number of technical publications have made microfilming arrangements and will be glad to give their subscribers the necessary information. University Microfilms also stands ready to offer suggestions for viewing equipment suitable for a variety of needs and budgets.

A call for new information on corrosion inhibitors has been received from Aaron Wachter, Shell Development Co., Emeryville 8, Calif., the chairman of an N.A.C.E. committee on the subject. The committee is interested in information resulting either from research or field experience, and whether in the form of short observations or full technical papers.

(Continued on page 8)



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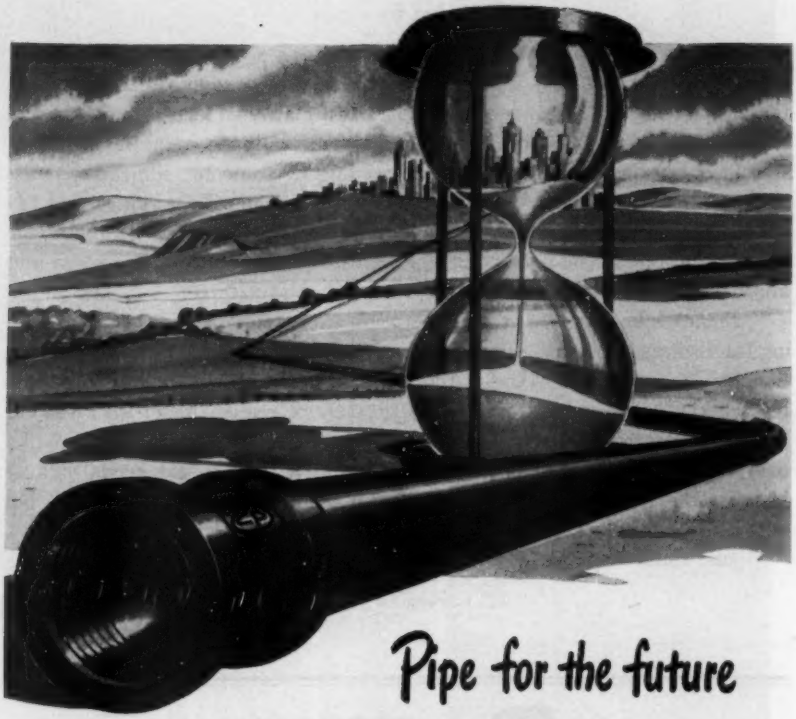

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(*Continued from page 6*)

Where there's smoke, these days, there's a silver iodide generator at work—out West, at least, where one commercial rainmaker already has more than 300,000,000 acres under contract. As a matter of fact, rainmakers and antirainmakers, both, agree that there are virtually no areas in the West that have not been subjected to cloud seeding by someone, somehow, sometime. That lack of control areas, incidentally, is one of the things that has caused the U.S. Weather Bureau to take such a dim view of the whole subject and one of the reasons why congressmen are now being pressed into another "investigation"—only, this time, a "scientific" one.

Meanwhile, on other fronts, the rainmakers have been accused of causing the Kansas flood, the New Mexico drought and sundry other excesses and deficiencies of Nature. And in the Yakima Valley of the state of Washington, cherry growers have given us a preview of really "unsettled" weather by hiring nonrainmakers to follow the wheat growers' rainmakers and to overseed the seeded clouds, thus to stop the rain the wheat needs because it splits the ripening cherries. Not who owns the clouds any more, but who's going to tell them what to do!

Just think—not five years ago people used to pray for rain!

(*Continued on page 10*)

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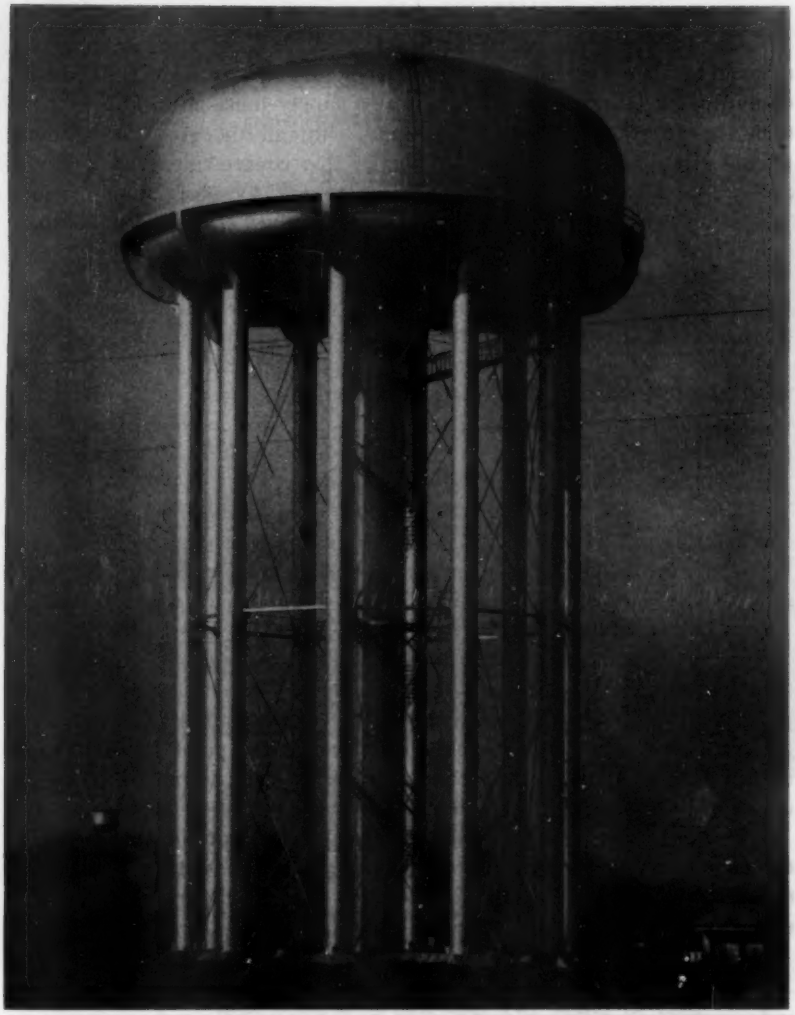

Third Radial-Cone Tank at Jackson

This 1,000,000-gal. tank is the third Horton elevated tank of the radial-cone design, installed in the Jackson, Miss., water distribution system. The other two tanks have a capacity of 500,000-gal. each. One was installed in 1938 and the other one in 1940. Write our nearest office for estimates on elevated tanks when planning water improvements.

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(*Continued from page 8*)

Capital is the new word for fluoridation. At any rate, any program that can obtain congressional approval as quickly and as easily as did fluoridation of the District of Columbia water supply must be capital in more than the geographic sense. Of course, with all the gum-beating done around Washington, there's little wonder that congressmen are so tooth-conscious. But, gnash or no, the current D.C. appropriation includes $130,000 to cover the capital expenditures involved in initiating fluoridation in the nation's capital.

Kaput, rather than capital, might the word have been if congressmen had had a chance to read and believe the "Science" section of the New York *Herald-Tribune* which issued only a few days after their action. There it was indicated that fluoridation had "held the spotlight for a while, but carious teeth continued," and now, presumably, that method of treatment is as extinct as "calories, balanced diet, hormone influence, sunshine, the toothbrush or vitamin control" in caries control.

Up-to-date thinking, according to the *Tribune* article, suggested exercise or table salt as the real answers. First of these denticeas is that of Dr. H. H. Neumann, a pediatrician at the School of Dental and Oral Surgery of the Columbia University School of Medicine, whose extensive studies have led him to conclude that "tooth decay results from regressive conditions in the mouth structure caused by inadequate use of the teeth and associated muscles." The other idea is that of Dr. Charles F. Bodecker, professor emeritus of the same school, who indicates that "the sound approach is to try to keep the acid-alkali level at the point found in most healthy mouths (pH 7.0–7.5)," and that this is easily accomplished by the use of ordinary table salt as a dentifrice.

Harking back to the capital, we take skeptical note of a reference to the fact that caries-conscious congressmen give at least their "associated muscles" a phenomenal amount of exercise. And on these humid days our salt shakers won't work anyway.

(*Continued on page 12*)

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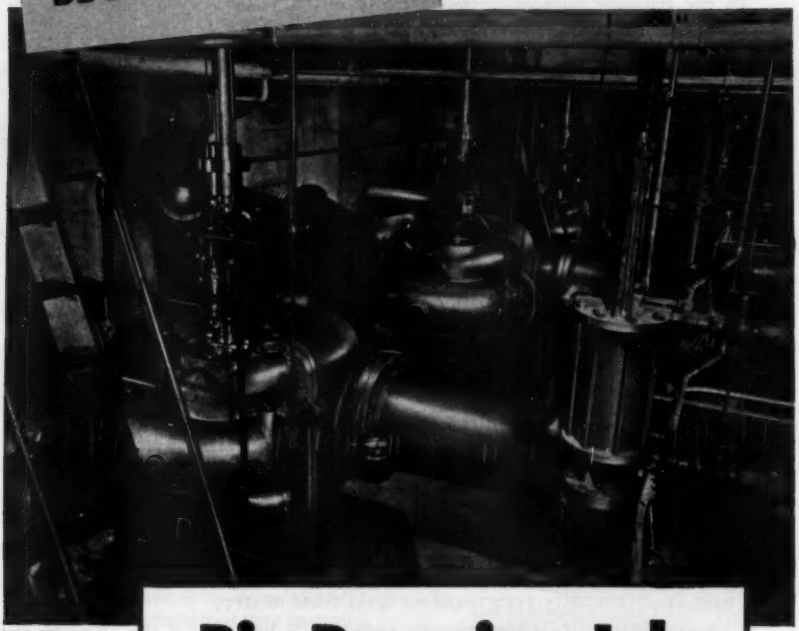

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Big Pumping Job

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These De Laval vertical low-head centrifugal pumps are space-savers. That's one important reason they were chosen by the City of Flint, Michigan to handle river water at their 135 mgd filtration plant. • Vertical pumps also permit driver to be located above flood water level. Result? De Laval pumps stay on the job, even under emergency conditions.

50th Anniversary

DE LAVAL Centrifugal Pumps

DE LAVAL STEAM TURBINE COMPANY
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(*Continued from page 10*)

The recurrence of National Employ the Physically Handicapped Week (October 7–13) during a period when manpower shortages are again acute serves as a reminder that, in the President's words:

> In the nation's physically handicapped lies a vast reservoir of relatively untapped skills. These skills, properly utilized, constitute a mighty bulwark against the present threat of manpower shortages. They must not be overlooked in our preparedness program. Qualified handicapped workers not now employed should be employed. Those not trained should be trained, screened for maximum usefulness and given the opportunity to contribute their skills and abilities.

A recent advertisement in the JOURNAL depicted a blind repairman working at his bench in a large meter repair shop. Innumerable examples of the use of persons handicapped in various ways in a multitude of capacities are evidence that, when correctly placed, a person's physical disability is no handicap to the performance of his job.

What Price Water might have been decided by the Office of Price Stabilization if some politically potent A.W.W.A. members hadn't intervened to kill a floor amendment to the defense production and economic stabilization legislation in Congress last July. The amendment, stuck in after both Senate and House had killed the proposal in committee, sought to bring under OPS control all rates charged by publicly owned utilities not already under the control of a public regulatory authority. The fact that the amendment was adopted after a full three minutes' consideration indicates just how seriously congressmen hold their water.

Concurrently, it is interesting to note, OPS had pulled the stopper on such water as it did control, exempting the sale of bottled water, either natural or distilled, from regulation, with the note that such water had little or no effect on the cost of living and that the expense of establishing and enforcing price ceilings would thus not be warranted. Meanwhile, waters polluted in any way—by flavor, for instance, or carbonation, or malt and hops—continued covered.

Having bought our share of at least the last-named of these and having shopped for our share of other controlled items, we're not entirely sure that one of those ceilings unlimited wouldn't have been just the thing for water utilities. Then they could leave to OPS the problem of selling their rate rises to their public.

A new chemical feeder is being offered by Mathieson Chemical Corp., specially designed to handle its high-test calcium hypochlorite (HTH) in tablet form. The equipment dissolves the tablets and dispenses the resultant solution at rates which can be adjusted to a wide range of operating demands.

(*Continued on page 14*)

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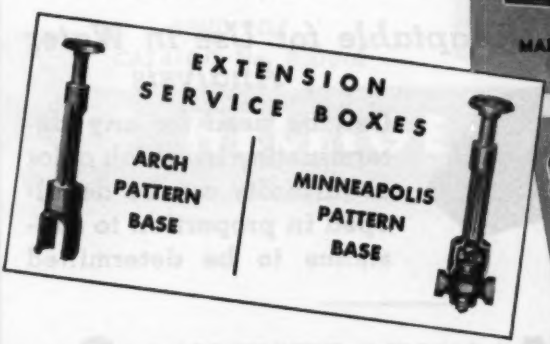

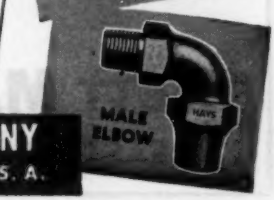

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(Continued from page 12)

A tragic accident resulted in the line-of-duty death of Joseph F. Bristow, engineer in charge of construction for the Water Supply and Sewerage Dept. of Brisbane, Australia. Formerly assistant engineer with the department, he had been promoted only a few weeks before his death, which occurred while he was inspecting a large construction project.

Earle L. Waterman, professor of sanitary engineering and head of the Dept. of Civil Engineering at the University of Iowa, died on July 30 after a long illness. He was 65. Associated with the university for 32 years, and chairman of his department since 1944, he had been teaching only part-time since 1949 because of ill health.

"Text needs in the fields of fluid mechanics and applied hydraulics" is the subject of a survey conducted by Carl E. Kindsvater, professor of civil engineering at Georgia Inst. of Technology, acting for the American Society of Engineering Education. The aim of the study was to spotlight deficiencies in textbooks available in theoretical fluid mechanics and hydraulic engineering, so that authors and publishers alike might remedy them.

(Continued on page 16)

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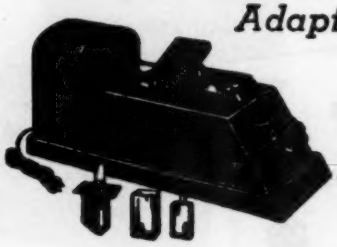

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(*Continued from page 14*)

Work on cleaning up the Ohio River basin has been proceeding at a rate gratifying to the Ohio River Valley Water Sanitation Commission, which reports that 39 per cent of the wastes from the 8.5 million people in the area is now receiving some sort of treatment and that new plants under construction will serve another 8 per cent. Plans already approved (20 per cent) or in preparation will add 37 per cent to this total, provided that financing can be obtained and materials shortages do not interfere.

The best defense was a bad offense to a lot of our British friends when someone in their government imported 20,000 cans of U.S. water for the defense stockpile. "Why," was the cry, "is this water more useful for such purposes than the water of our own islands?" And in the House of Commons, pointing out "the considerable amount of ridicule cast upon the policy of His Majesty's Government by the story," M.P.'s put the bee on the president of the board of trade to find out who ordered said cans and why. Less put out than perhaps would have seemed seemly, the British Waterworks Association suggested in its journal that perhaps "an explanation of this mystery is that the American admiral was bringing over his own water" —all of which indicates a much better understanding of Americans than of admirals. Certainly no admiral would be that fussy about the water he bathed in, and even more certainly no admiral would drink the stuff!

No, B.W.A., more likely a frame-up by one of your own Conservatives!

Cats-up was more predicament than condiment the other day at Westport, Ind. All told, there were seven cats—four of them kittens, none of them kin—up on the town's 100-ft. water tower, and the saving of their 63 lives was no mean problem. As a matter of fact, although catcalls had rent the air for several hours, Westportians didn't realize they weren't being serenaded by lovesick catbirds until they received the high sign from some dogs who could apparently write. Informed, the police dispatched a rescue party which was able to capture the kitties without incident and lower them by rope into the arms of their owners.

If it hadn't been for the anonymous message by some conscience-stricken culprit, we might have had some fun speculating on feline motivation. Now, however, we can't even suppose that someone trying to drown some kittens just headed for the nearest water. Anyway, bats in the belfry ain't nothing compared with Westport's cats in the clouds.

William R. Wolff has been advanced from associate to chief hydraulic engineer of the New York State Public Service Commission.

(*Continued on page 18*)

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(*Continued from page 16*)

N.S.F. was not so funny when it appeared on the paychecks of the 474 employees of the city of Hamtramck, Mich., last July. What it meant was that the 1951–52 city budget had not yet been approved and that none of the city employees could be paid until it was. Meanwhile, water came to the rescue, funds from its account being transferred, with city council approval, to liquidate the old year's July 1 payroll of $45,200. Actually, tax accounts receivable at the time totaled some $2,000,000, but were uncollectible for lack of the $375 postage required to mail the bills.

By mid-July, the N.S.F. had turned to I.O.U., but employees were still sticking to their jobs through what some claimed to be force of habit.

George E. Symons has resigned as managing editor of *Water & Sewage Works* magazine to establish an independent consulting service in Larchmont, N.Y. He plans to offer both engineering and writing services to the water, sewage and industrial waste treatment fields. In addition, he will maintain an editorial connection with *Water & Sewage Works,* serving as contributing editor to that publication. Immediately before entering the publisking field, he had been chief chemist of the Buffalo, N.Y., Sewer Authority.

(*Continued on page 80*)

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Here's a bible of bark and bite that will enable you to improve both your personnel relations and your public relations. See that every meter reader gets a copy. Make him read it! Make him heed it!

Under the cover reproduced herewith, A.W.W.A. has, in response to the demand of several meter departments, reprinted Bruce McAlister's "Bow-wow, Mister Meterman" as it appeared in the July 1949 issue of **Public Relations at Work.** As a six-page booklet, this practical advice to the doglorn is now available at a nickel per copy—much less than the cost of a single patch in the seat of your pants.

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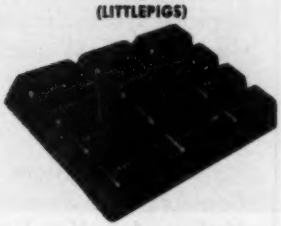

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The Conservation of Ground Water. *Harold E. Thomas. McGraw-Hill Book Co., New York (1951) $5.00.*

Ground water is plentiful in many areas of the U.S. but it is not inexhaustible. Intelligence and care must be exercised in its use. This book cites approximately 60 examples of ground water use and misuse. Overdraft and the attendant introduction of unusable water are generally attributed to a lack of knowledge of the principles governing yield. Examples of the application of corrective policies are also included. Ground water problems resulting from land occupancy are reviewed as are the needs for additional research, and a strong plea is made for better ground-water development and management. The chapter on management is written by Abel Wolman.

The book, in pointing out the abuses and weaknesses of present ground water practices, carefully marks the way for the development of a sound ground water policy based on research and field investigations by people specifically trained for the work. This volume, the preparation of which was sponsored by the Conservation Foundation, is recommended reading for the water works profession, engineers and conservationists.

Public Relations for Public Officials: Selected References. *Eric Carlson. Assn. of Municipal Public Relations Officers, 341 Madison Ave., New York 17, N.Y. (1951) 50¢*

This mimeographed bibliography of books and articles on public relations has been prepared for the use of municipal and other public officials, and lists a wealth of material useful to those in charge of a public relations program for water utilities. Among some of the specialized topics for which references are listed are community leadership, community public relations, municipal and annual reports, and various public relations techniques, including advertising, public speaking and the use of visual aids. Although it occupies only fourteen mimeographed pages, the booklet offers a valuable tool to workers in this field.

(Continued on page 22)

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The Reading Meter

(Continued from page 20)

Stainless Steel Handbook. *Allegheny Ludlum Steel Corp., 2020 Oliver Bldg., Pittsburgh 22, Pa. (1951) free to stainless steel users.*

A new edition of the data manual issued by Allegheny Ludlum offers information on proper steel selection for specific applications, properties and characteristics of nearly 40 different types of steel, much data on corrosion resistance to various chemicals and other substances, and details of heat treatment and fabrication. The volume is handsomely printed and cloth bound.

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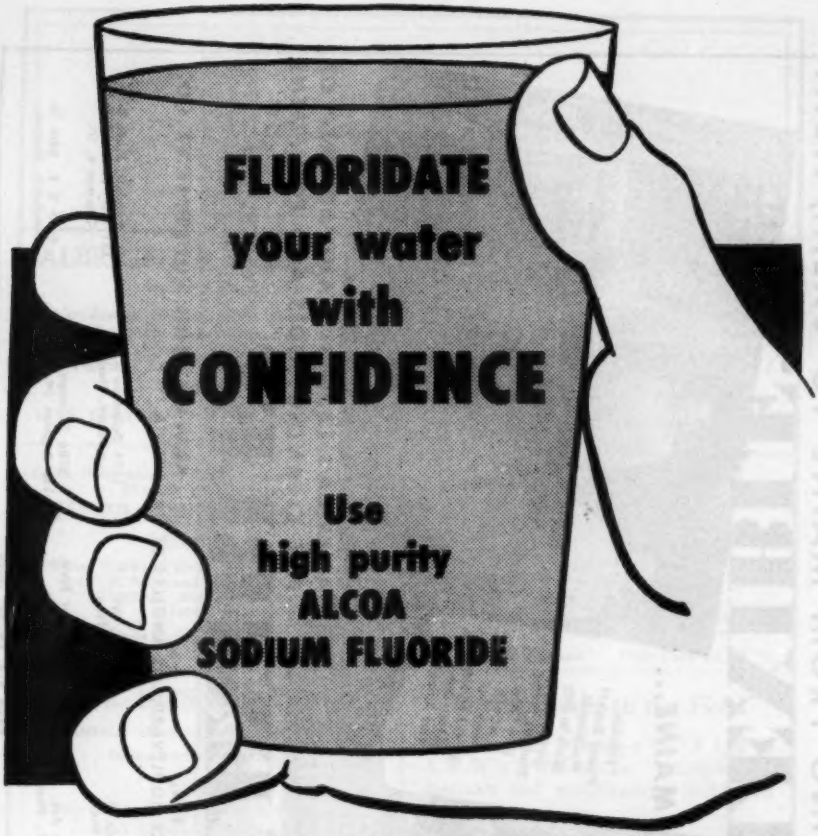

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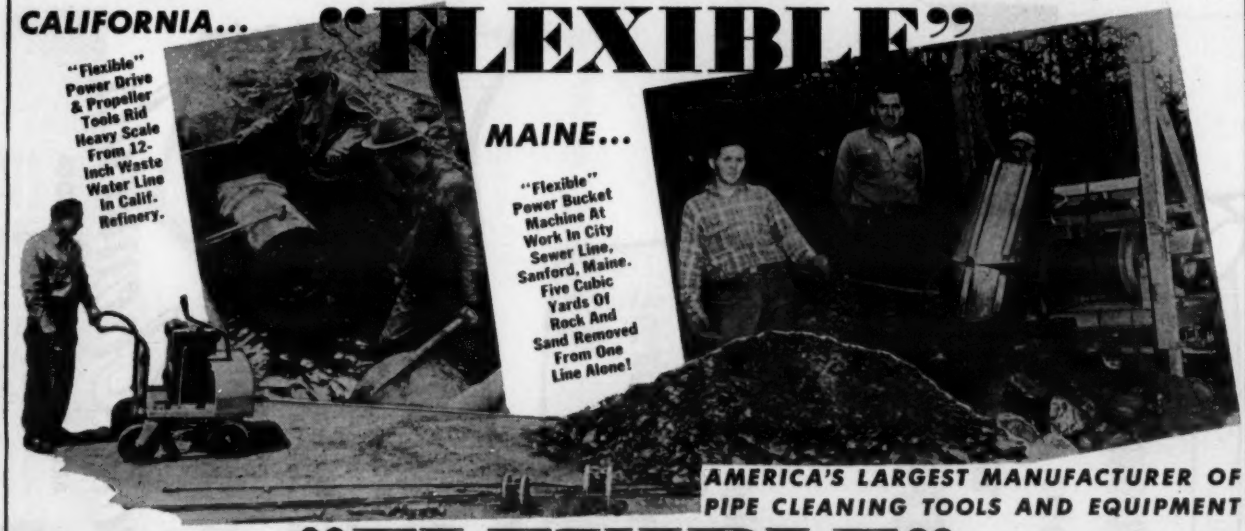
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Membership Changes

NEW MEMBERS

Applications received July 1 to July 31, 1951

Alabama Pipe Co., J. W. Perry, Jr., Southern Sales Mgr., Box 791, Anniston, Ala. (Assoc. M. July '51)

Albertson Water Dist., Fred W. Dawson, Chairman, Board of Water Comrs., 175 I. U. Willets Rd., Albertson, N.Y. (Mun. Sv. Sub. July '51) *MPR*

Amos, Harold, Water Supt., Elk Rapids, Mich. (July '51) *MP*

Anadarko, City of, K. C. Finch, City Mgr., City Hall, Anadarko, Okla. (Corp. M. July '51) *M*

Atlantic Municipal Utilities, Raymond C. Dwyer, Supt., Atlantic, Iowa (Mun. Sv. Sub. July '51) *MP*

Bingham, Wesley, Water Foreman & Plumbing Inspector, City Water & Light Dept., 9 John St., Moncton, N.B. (July '51)

Blackford Window Glass Co., Gerald Moon, Water Treatment Plant Supt., Box 198, Vincennes, Ind. (Corp. M. July '51) *P*

Bowser, Reginald Burton, San. Engr., Dept. of Health & Welfare, City Hall, Halifax, N.S. (July '51)

Braun Corp., Gilbert E. Sinclair, Chem. Dept., 2260 E. 15th St., Los Angeles 21, Calif. (Assoc. M. July '51)

Bridgewater Public Service Com., D. R. Smith, Mgr., Bridgewater, N. S. (Corp. M. July '51)

Burns, Robert Earl, Sales Engr., Oliver B. Lyman, 55 New Montgomery St., San Francisco, Calif. (July '51) *P*

Central Park Water Dist., Albert A. Land, Chairman of the Board, Broadway, Bethpage, N.Y. (Mun. Sv. Sub. July '51) *M*

Christesson, Elzie J., Utility Mgr., Melrose, N.M. (July '51) *M*

Clark, J. P., *see* Rateonics Corp.

Dawson, Fred W., *see* Albertson (N.Y.) Water Dist.

Debison, William Henry, Water Supt., Caledonia Power & Water Board, Glace Bay, N.S. (July '51)

Dismuke, Pat, Supt., Water & Sewerage, Nashville, Ga. (July '51)

Dobrzensky, W. H., Mgr., Newman Water Works Co., 1109 Fresno St., Newman, Calif. (July '51)

Doucette, George, Mgr., Water & Sewerage Dept., Campbellton, N.B. (July '51)

Dwyer, Raymond C., *see* Atlantic (Iowa) Municipal Utilities

Eaton, William H., 221 S. Mill St., Clio, Mich. (July '51) *MPR*

Eckelcamp, Joseph, Supt. of Public Works, Spring Lake, Mich. (July '51) *MP*

Finch, K. C., *see* Anadarko (Okla.)

Francis, Robert L., Assoc. Chemist, Public Health Lab., State Dept. of Health, Box 1020, Bismarck, N.D. (July '51) *R*

Gaynor, Merle Thomas, Chief Engr., Dept. of Water Works, 5941 Calumet Ave., Hammond, Ind. (July '51) *M*

Glover, Herbert P., *see* Northwestern New York Water Authority

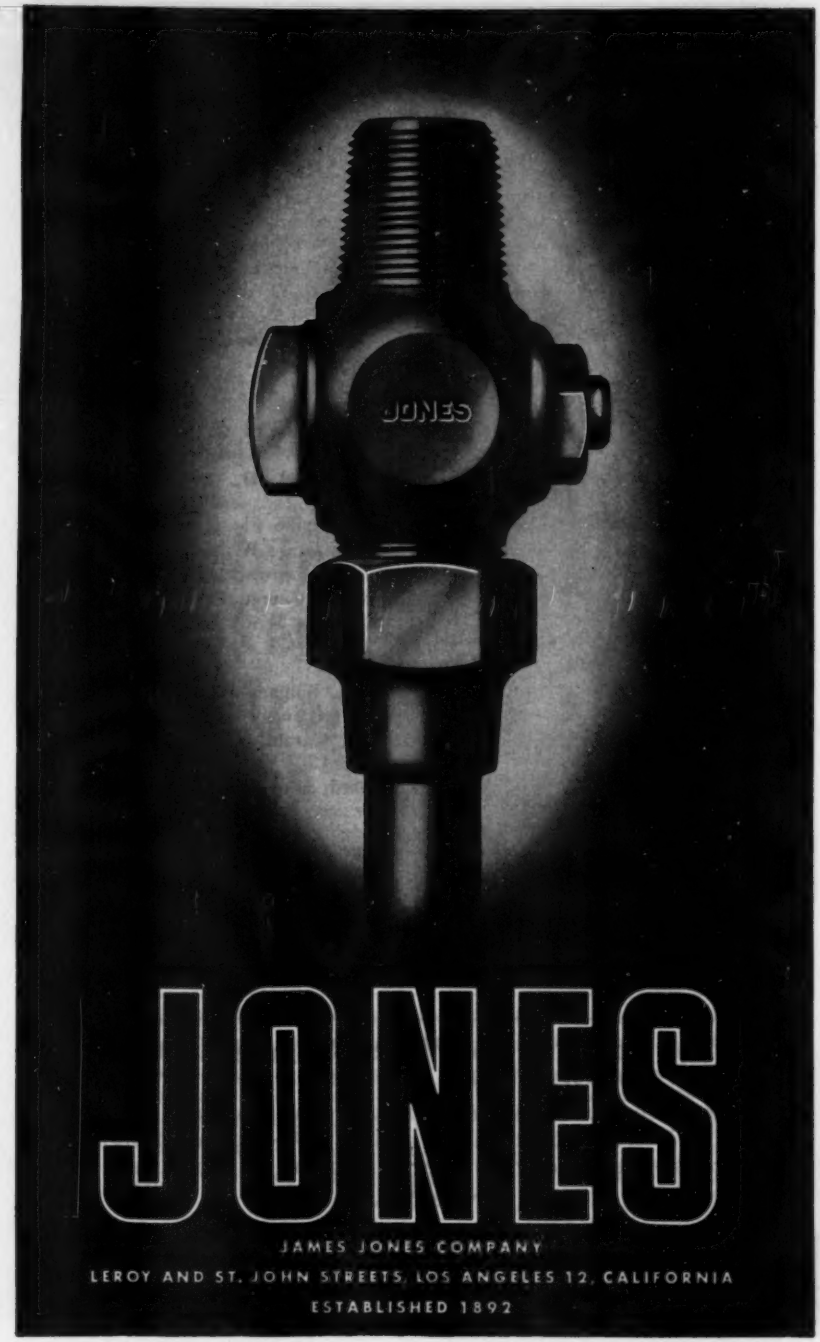
Gordon, W. Verner, Jr., Maritime Repr., Neptune Meters, Ltd., 77 Upper Water St., Halifax, N.S. (July '51)

Gork, L. Henry, City Mgr., 750 Lakeside Dr., S.E., East Grand Rapids, Mich. (July '51) *MP*

Greco, Edward Carl, Chemist, Research Dept., United Gas Corp., Box 1407, Shreveport 92, La. (July '51) *P*

Hammond Iron Works, Ralph E. Kramer, Vice-Pres., Warren, Pa. (Assoc. M. July '51)

(*Continued on page 32*)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(*Continued from page 30*)

Haney, John H., Power Engr., E. I. du Pont de Nemours & Co., Inc., Chambers Works Plant, Penns Grove, N.J. (July '51) *MP*

Hanily, John Edward, Owner, Culligan Soft Water Service, 4120 Perry N., Robbinsdale, Minn. (July '51)

Haratani, Joseph, Jr. Civ. Engr., Div. of Water Resources, 1079 Public Works Bldg., Sacramento, Calif. (July '51) *R*

Haskew, George Manders, Jr., Student, Massachusetts Inst. of Technology, 671 Summit Ave., Westfield, N.J. (Jr. M. July '51) *PR*

Hood, Leo Ray, Field Engr., Water Div., The H. C. Nutting Co., 4120 Airport Rd., Cincinnati 26, Ohio (July '51) *M*

Hurd, Frank Daniel, San. Engr., R. W. Petrie & Assocs., 557 Paw Paw Ave., Benton Harbor, Mich. (July '51) *PR*

Ingram, William Marcus, Biologist, Ohio-Tennessee Drainage Basins, Div. of Water Pollution Control, U.S. Public Health Service, 1014 Broadway, Cincinnati 2, Ohio (July '51) *PR*

Kern County Dept., of Public Health, Div. of Sanitation, Box 997, Bakersfield, Calif. (Mun. Sv. Sub. July '51)

Kramer, Ralph E., *see* Hammond Iron Works

Land, Albert A., *see* Central Park Water Dist.

Larkin, Donald G., Assoc. San. Engr., East Bay Municipal Utility Dist., 512—16th St., Oakland, Calif. (July '51) *P*

Larsen, Elwood Melvin, San. Engr., State Board of Health, Box 210, Jacksonville 1, Fla. (July '51)

Leynard, Arthur P., City Engr., 455 Wallace St., Nanaimo, B.C. (July '51)

Liberty Powder Defense Corp., William J. Meikle, Lab. Supt., Badger Ordnance Works, Baraboo, Wis. (Corp. M. July '51) *MP*

Lovett, Percy A., Partner, Engineering Service Co., 14 Prince St., Box 263, Halifax, N.S. (July '51)

Lyons, William E., Water Supt., Albertson Water Dist., Albertson, N.Y. (July '51) *MPR*

Matthews, Robert R., Jr., Engr., Water & Sewage Branch, Engr. Section, Hdq., 4th Army, Fort Sam Houston, Tex. (July '51)

Mayer, Kenneth L., Supt., City Hall, Monroe, Wis. (July '51) *M*

McDaniel, B. H., Development Engr., Dowell, Inc., 611 Graham Bldg., Jacksonville, Fla. (July '51) *MPR*

McGee, James W., Pres., Board of Water Comrs., Rahway, N.J. (July '51) *MPR*

McGinty, George Francis, Water Foreman, City Water Dept., City Hall, 100 N. Garfield Ave., Pasadena, Calif. (July '51) *M*

Meikle, William J., *see* Liberty Powder Defense Corp.

Moon, Gerald, *see* Blackford Window Glass Co.

Mulford, James E., Owner, Mulford Eng. Service, 33 W. 16th St., Chicago Heights, Ill. (July '51) *R*

Northwestern New York Water Authority, Herbert P. Glover, Secy., 5–6 Lohrmann Bldg., Lockport, N.Y. (Corp. M. July '51) *MPR*

(*Continued on page 34*)

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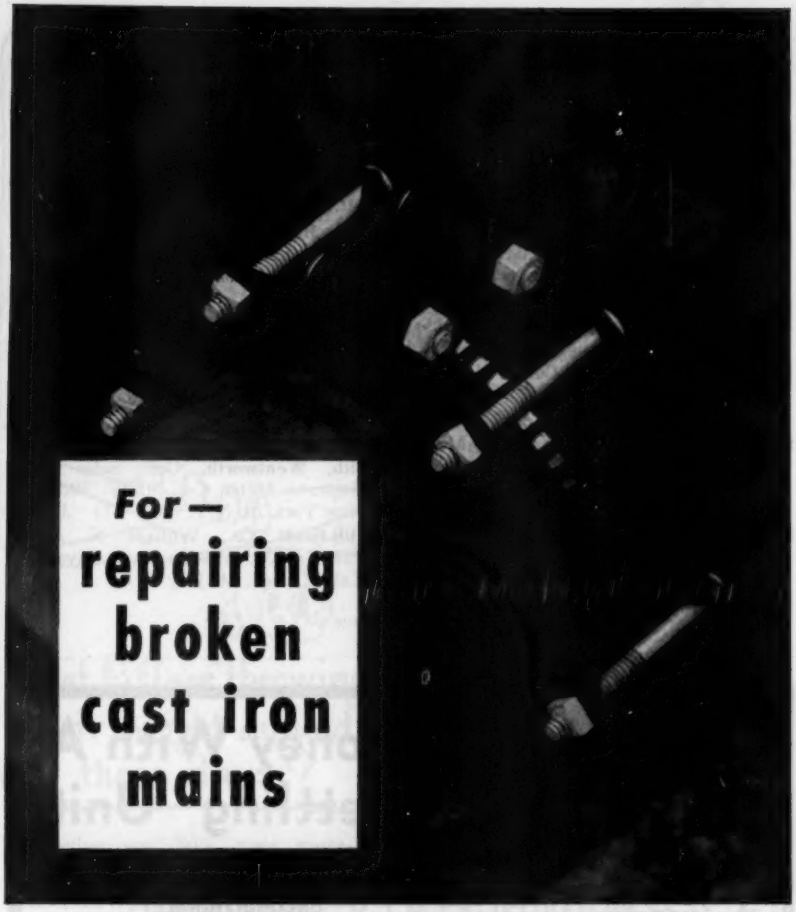

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(*Continued from page 32*)

Orgain, Holmes, San. Engr., State Dept. of Health, 5807 Willowton Ave., Baltimore 14, Md. (July '51)

Perry, J. W., Jr., *see* Alabama Pipe Co.

Quinn, Brent M., Mech. Engr., Dale Carlia Filter Plant, Army Corps of Engrs., 2201 G St., N.W., Washington, D.C. (July '51)

Rateonics Corp., J. P. Clark, Secy.-Director, Rate Dept., Rateonics Bldg., Dallas, Tex. (Corp. M. July '51) *MR*

Rea, W. L., *see* Rea, W. L., Construction Co.

Rea, W. L., Construction Co., W. L. Rea, 401 Westchester Dr., Corpus Christi, Tex. (Assoc. M. July '51)

Republic Supply Co. of California, M. S. Yunker, Asst. Mgr., Industrial Sales, 2600 S. Eastland Ave., Los Angeles 54, Calif. (Assoc. M. July '51)

Robinson, Albert F., Director of Water, Water Dept., Fairmont, W. Va. (July '51)

Rogers, M. H., Supt., Box 60, Bathurst, N.B. (July '51)

Schenk, Robert James, Asst. Water Supt., Western Light & Telephone Co., Inc., 2015 Forest Ave., Great Bend, Kan. (July '51) *M*

Scott, William N., *see* Smith-Scott Co.

Shuey, Bruce Stanley, Asst. Supervisor of Water Purification, Filtration Plant, City Water Works, Cincinnati 28, Ohio (July '51) *P*

Silva-Mujica, Alvaro, Civ. Engr., Calle 13, No. 9–13, Bogota, Colombia (July '51) *PR*

Sinclair, Gilbert E., *see* Braun Corp.

Smith, D. R., *see* Bridgewater (N.S.) Public Service Com.

Smith, Wentworth, Gen. Sales Mgr., Neptune Meter Co., 50 W. 50th St., New York 20, N.Y. (July '51) *M*

Smith-Scott Co., William N. Scott, Partner, 6565 Mission Blvd., Riverside, Calif. (Assoc. M. July '51)

(*Continued on page 38*)

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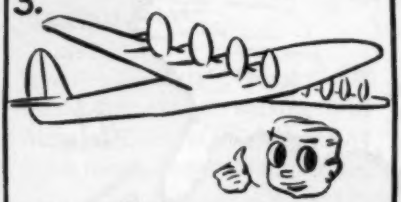

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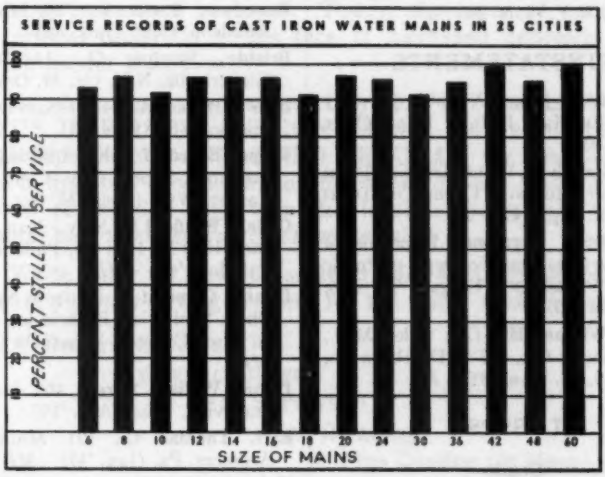

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SERVES FOR CENTURIES

(*Continued from page 34*)

Stewart, Clarence P., Water Supt., Tyler, Tex. (July '51) *M*

Swan, R. R., Village Clerk, Vicksburn, Mich. (July '51)

Swatek, Charles M., *see* Swatek, M. A., & Co.

Swatek, M. A., & Co., Charles M. Swatek, Pres., 519 Hightower Bldg., Oklahoma City 2, Okla. (Assoc. M. July '51)

Thibodeau, Tilmon, Town Clerk, Campbellton, N.B. (July '51)

Voorhees, Clint, Supt. of Public Works, Board of Public Works, Dowagiao, Mich. (July '51) *MR*

Ward, Richard C., Partner, Ward & Moore, Cons. Engrs., 126 Pine St., Corning, N.Y. (July '51)

Whittle, R. D., *see* Whittle Construction Co.

Whittle Construction Co., R. D. Whittle, Owner, 3102 Kings Row, Dallas, Tex. (Assoc. M. July '51)

Yunker, M. S., *see* Republic Supply Co. of California

Zuckert, Warren M., Dist. Repr., The Permutit Co., 330 West 42nd St., New York 18, N.Y. (July '51) *P*

REINSTATEMENTS

Holton, City of, James W. Bibb, Jr., City Mgr., City Hall, Holton, Kan. (Corp. M. Jan. '49)

Humber, Joseph B., Water Treating Plant Supervisor, Monsanto Chem. Co., Texas City, Tex. (Apr. '47) *P*

Mason, Ernest Raymond, Inspector of Mech. Services, Ontario Dept. of Public Works, Parliament Bldgs., Toronto, Ont. (July '43)

Mitchell, William H., Dist Sales Mgr., The Permutit Co., 407 S. Dearborn St., Chicago 5, Ill. (Jan. '35) *P*

LOSSES

Deaths

Bristow, Joseph Francis, Asst. Engr., Water Supply Dept., City Council, Jolimont St., Sherwood, Brisbane, Queensland, Australia (Jan. '45)

Stern, Sollis E., Supt., Frankfort City Water Co., Frankfort, Ind. (May '33)

Waterman, Earle Lytton, Prof. of San. Eng., 231 Fairview Ave., Iowa City, Iowa (Dec. '22) *Director '38–'41. Fuller Award '45.*

Resignations

Austin, H. B., Austin Eng. Co., 115 S. Jefferson St., Peoria, Ill. (Jan. '41) *P*

Perazzo, Roberto J., Civ. Engr., Administracion Nacional del Agua, Potosi 4052, Buenos Aires, Argentina (Jan. '45)

Stravinski, Ceaser A., Assoc. Public Health Engr., State Board of Health, 453 State Office Bldg., Madison, Wis. (Oct. '49)

CHANGES IN ADDRESS

Changes received between July 5 and August 5, 1951

Archibald, H. E., City Engr.'s Dept., City Hall, Hamilton, Ont. (Oct. '47) *M*

Avrett, William L., Jr., Public Health Dept., SVPM, Palembank, Sumatra, Indonesia (Apr. '36) *P*

Baker, Donald M., Cons. Engr., 448 S. Hill St., Los Angeles 13, Calif. (Oct. '34)

Benedum, Burtis A., 780 Morada Pl., Altadena, Calif. (Jan. '45)

Brisbin, Sterling G., 14—2nd Ave. Gloversville, N.Y. (Jr. M. Oct. '50)

Brown, Horace A., 648 DeSoto Dr., Miami Springs, Fla. (June '11)

Casper Board of Public Utilities, Roel K. Stratton, Supt., City County Bldg., Casper, Wyo. (Corp. M. Oct. '37)

Codell, Winfield S., Secy., Alan A. Wood, Inc., 4610 N. 15th St., Philadelphia 40, Pa. (Jan. '45) *MPR*

Denize, Clement F., Instituto Nacional de Obras Sanitarias, Edificio las Mercedes 2d Piso, Caracas, Venezuela (July '49) *MP*

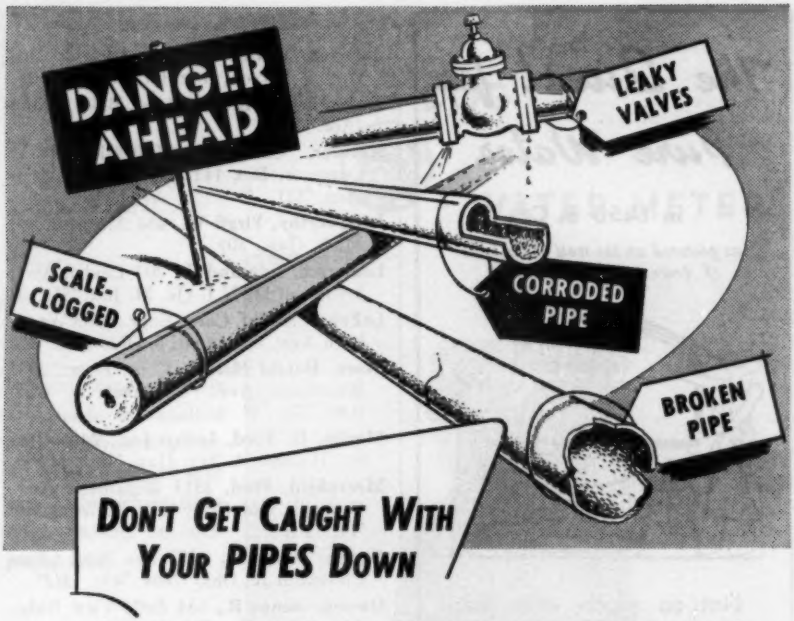
Dunn, William Carey, 406 Hogan St., Starkville, Miss. (Apr. '19)

Earl, Thomas C., 191 Midfield Rd., Ardmore, Pa. (Jan. '47) *MP*

Hale, Harrison, Head, Dept. of Chemistry, Southern State College, Magnolia, Ark. (Jan. '40) *P*

Hobson, J. R. A., Jr., Eng. Dept., West Virginia Pulp & Paper Co., 230 Park Ave., New York 17, N.Y. (Jan. '48) *MR*

(*Continued on page 40*)



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(Continued from page 38)

Johnson, Walter K., 1743 Adelaide Dr., Apt. 5, Tucson, Ariz. (Jr. M. Jan. '50)

Jones, James R., Box 1384, Boise, Idaho (Apr. '49)

Kensler, Calvin T., Filtration Plant Operator, Box 141, Huntingburg, Ind. (Jan. '51) *P*

Langworthy, Virgil W., 454 Allis, Adrian, Mich. (Jan. '50)

Laubusch, Edmund J., 203 Linden Ave., Irvington 11, N.J. (Jr. M. Jan. '51) *P*

LeFeber, Alfred, Cons. Engr., 2933 Woodburn Ave., Cincinnati 6, Ohio (Jan. '47)

Mace, Harold Harlan, Cons. Engr., 2933 Woodburn Ave., Cincinnati 6, Ohio (Oct. '37) *P*

Martin, H. Fred, Infilco Inc., 2425 Binz St., Houston 4, Tex. (Jan. '46) *MPR*

Merryfield, Fred, 3513 Willamette Ave., Corvallis, Ore. (May '34) *Fuller Award '44. PR*

Ogden, Willis L., 1853 Lee Blvd., East Cleveland 12, Ohio (Nov. '43) *MP*

Owens, James B., 634 Belle View Bldg., Alexandria, Va. (Oct. '47)

Pflanz, E. L., 612½ S. Matanzas Ave., Tampa, Fla. (July '35) *MP*

Phlen, Ernest Arvil, San. Engr., The Institute of Inter-American Affairs, Apartado 23, Bis, Mexico, D.F., Mexico (Apr. '51) *MPR*

Riehl, Merrill, L., Box 298, Youngstown 1, Ohio (Apr. '40) *P*

Seidel, Harris, F., Ames, Iowa (Jan. '46) *PR*

Seppa, Karl E., Div. Sales Engr., Armco Drainage & Metal Products, Inc., 2348 Eccleston, Walnut Creek, Calif. (Oct. '50)

Shiner, Stephen, 41 Hawthorn Ave., Toronto, Ont. (Jan. '49)

Shoup, Robert E., 613 E. Main St., Van Wert, Ohio (July '48)

Small, Leon, Brinklow Post Office, Montgomery County, Md. (Jan. '36) *Fuller Award '48. M*

Sohle, Frederick Victor, Sales Mgr., R. D. Wood Co., 6617 Snider Plaza, Dallas, Tex. (Oct. '42)

Souder, Byron N., 7177 Village Dr., Mission, Kan. (Jan. '43) *PR*

Staley, Henry H., c/o Dist. Engr., A.P.D. 942, c/o Postmaster, Seattle, Wash. (July '38)

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Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain); C.A.—Chemical Abstracts; Corr.—Corrosion; I.M.—Institute of Metals (Great Britain); P.H.E.A.—Public Health Engineering Abstracts; S.I.W.—Sewage and Industrial Wastes; W.P.A.—Water Pollution Abstracts (Great Britain).*

ANNUAL REPORTS

Metropolitan Water Dist. of Southern Calif. Annual Report (July 1, 1949–June 30, 1950). Softened filtered Colorado R. water supplied to all constituents in Los Angeles and Orange Counties, except San Marino. Total delivery 72,936 acre-ft., avg. rate 100.7 fps. Also 69,308 acre-ft. unsoftened water supplied to San Diego County and smaller amts. to other users. Max. monthly delivery of Colorado water 311.5 fps. or 201 mgd., and min. 95.2 mgd. Total production of all dist. constituents from all sources avgd. 594 mgd., approx. 170 gpcd. Area and pop. of dist. constituents 914 sq.mi. and 3,352,074, resp. Pop. of entire coastal area which can be supplied with Colorado water 5,250,000. Colorado R. Aqueduct Assn. organized in '24, Metropolitan Water Dist. in '28. Constr. started in '32. First delivery in '41, guaranteeing adequate supply for every constituent area. San Diego aqueduct (71 mi.) completed in '47. Constr. cost to date of Colorado R. aqueduct, incl. northern half of San Diego Aqueduct and half power plant at Parker Dam, approx. $206,550,000. Main aqueduct consists of 5 pumping plants, 230-kv. transmission system bringing power from Hoover Dam, half Parker power plant and appurtenant dams, reservoirs and tunnels. From Intake power plant on Calif. shore of Lake Havasu, approx. 2 mi. upstream from Parker Dam, aqueduct extends 242 mi. to Lake Mathews in Cajalco basin south of Riverside where large storage developed at head of distr. system (maintained usable storage 80–100,000 acre-ft.). Dist. has rights to sufficient elec. energy produced to pump 800,000 acre-ft. annually through aqueduct lift of 1617 ft. District's allocation of Hoover Dam power 35.3%, that unused resold. Rates for firm and secondary energy at Hoover Dam 1.314 and 0.436 mills per kwhr., resp. Distr. system (wholesale only) 177.6 mi., excl. San Diego Aqueduct. Near La Verne, water diverted into softening and filtn. plant and then returned to upper feeder. Org. growths in San Diego Aqueduct controlled by chlorination. Growth of diatoms and protozoa in Lake Mathews required $CuSO_4$ treatment in Feb. —15 lb. per acre sprayed as powd. Recreational use of dist. reservoirs not permitted. Purif. plant capac. increased from 100 to 200 mgd. Facilities added: 2 flocculators, 2 clarifiers, 12 rapid sand filters, 12 ion exchange softeners, brine filters, lime feeder for pH correction. Before completion, original plant operated in excess of capac. and effluent hardness exceeded desired 125 ppm. value in July and Aug. Partial lime softening preceded ion exchange softening for 2 mo.; ion exchange used alone during rest of yr. Recent study showed zeolite softening only more economical than prelim. lime treatment aided by coagulant. Max. flow through plant 137 mgd., avg. 67. Sodium silicate applied to softener influent to reduce dissolution of siliceous zeolite. Normal useful life of latter more than 4 yr., during which well over 2 mil.gal. water softened per cu.ft. Synthetic siliceous zeolite in new sof-

(Continued on page 44)

flow capacity is GREATER THAN EVER in this pipe...

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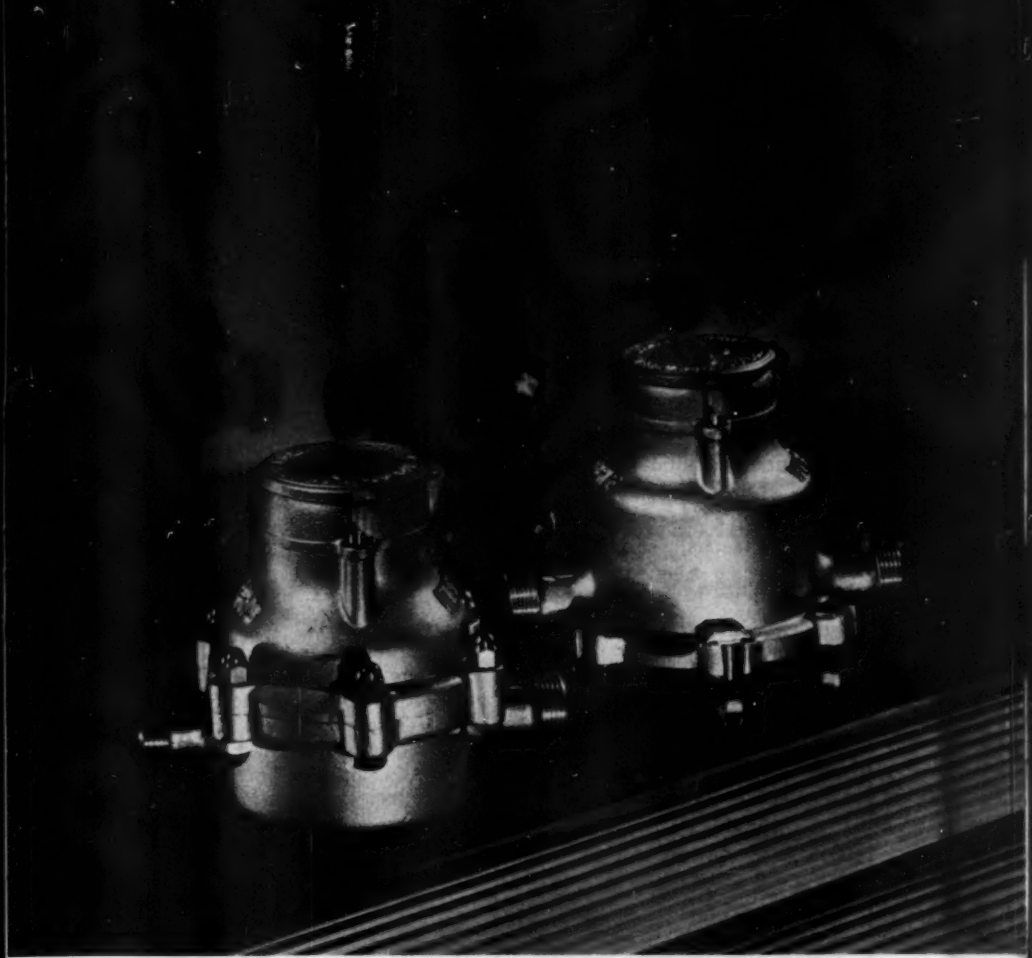
(*Continued from page 42*)

tening units. Pilot and plant scale studies indicated marked superiority of one type resinous cation exchanger, to be used in future to replace exhausted siliceous zeolite. Expts. being conducted on partial electrolytic softening process in 150-gpm. unit. Agitation with air jet at application point of lime for pH correction in zeolite effluent channels prevents pptn. of $CaCO_3$ at that point. Plant results: avg. total solids increased from 666 to 693 ppm., total hardness reduced from 321 to 127, carbonate hardness from 117 to 109, noncarbonate 204 to 18, pH increased from 8.4 to 8.9, elec. cond. ($EC \times 10^6$) 1035–1100. Regeneration water 3.1% of softened water, 1.9% of plant influent. Avg. hardness influent 305 ppm., effluent 13 ppm., parts salt per part hardness removed 2.4. Coliform completed positive tests in 10 ml. Colorado R. water 7.8%, softened O, distr. system 0.1%. Quality of regulated outflow from Lake Mead showed continued improvement, with less avg. hardness and salinity. Aiding this is gradual removal of slightly sol. minerals by leaching from reservoir area, formerly saline desert region. Natural softening of stored water by deposition of lime as white ring around shoreline and on reservoir bottom continued. Rainfall Los Angeles 10.6", 70% of 73-yr. avg. of 15.15", sixth successive subnormal yr. Tax rate of Dist. decreased from 50¢ per $100 assessed value in '46–7 to 34¢ in '49–50, chiefly due to expenses remaining comparatively const. Assessed valuations increased materially. Basis of valuation 50% of fair market value. Assets: permanent works $206,544,729, total $293,135,620. Outstanding bonds $180,527,000, contractual obligations $13,711,500. Receipts: taxes $14,821,288, water sales $2,093,216, other $1,162,862, total $18,077,366. Expenditures $16,002,160, of which $7,182,030 is bond interest and $2,339,000 bond

(*Continued on page 46*)

HERSEY



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(*Continued from page 44*)

redemption. Cash balance and govt. bonds held in various funds $28,899,-686.—*R. E. Thompson.*

Houston (Tex.) San. Eng. Sec., Water Div. Annual Report (1950). Major problem improving san. condition of 17 water systems added to city system by annexation and providing san. supervision to private water systems within new city limits. System again recommended for full certification by state dept. of health. Completion of 6 new wells increased no. of deep artesian wells in city system to 51. San. surveys made of 34 private water systems within city limits and 17 connected to city system; 4 others acquired at end of yr., leaving 13 private systems. Lab. control of these established and improvements secured where needed. Prechlorination ahead of reservoirs only treatment required. Cl demand curves made for all wells, and dosage adjusted to give 0.7 ppm. residual. Equip. includes 24 chlorine feeders and 4 residual recorders. Cross-connection control included 112 new surveys, 221 resurveys—11 cross connections eliminated. Approx. 150 mi. city mains, entire distr. systems of 3 private utilities connected during yr. Also 3 reservoirs and gravel for new wells disinfected. Bact. examns. made 14,053, complete chem. anals. 250, partial 1108. Pop. served more than 600,-000, avg. production 64.6 mgd., services 112,567. Avg. Cl dosage 1.55 ppm., avg. residual 0.69, Cl cost per mil.gal. 38.74¢. Elim. of dead ends in distr. system recommended.—*R. E. Thompson.*

Oak Park (Ill.) Water Department. Annual Report (1950). Supply from Chicago system, by pumping. Water rates reduced 10%. No uncollectable accts. charged off for fourth consecutive yr. Current assets $370,311, fixed $1,451,024, less depn. reserve $1,195,-

(*Continued on page 48*)

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(Continued from page 46)

754, other funds $37,101, total assets $662,683, surplus $627,516. Water sales $588,783, total income $592,814, operation and maint. (including $170,830 paid for water) $338,418, transferred to other funds $278,670, net loss $24,275. Pumps 8, total capac. 24 mgd., reservoir 5 mil.gal. Water purchased 2129 mil.gal., delivered 1885, loss 10%. Avg. consumption 5.72 mgd., 88 gpcd. to estd. 65,000 pop. Mains 109 mi., valves 1007, hydrants 1126, services 12,246, 100% metered. Total revenue per 1000 gal. 28.06¢, operation and maint. 16.02¢, paid to Chicago 8.021¢.—*R. E. Thompson.*

Augusta (Me.) Water District. Annual Report (1950). Dist. created in '03 to acquire Augusta Water Co., which supplied filtered Kennebec R. water. Typhoid prevalent at time. River supply abandoned in '06 for gravity supply from Carleton Pond, supplemented by water from Cobbosseecontee Lake when necessary. Chlorination begun in '23. In '26, 10-mil.gal. reservoir installed, increasing storage to 16 mil.gal., about 1-wk. supply. District's affairs governed by board of 3 trustees, 1 elected annually by municipal officers of Augusta for 3-yr. term. Trustees appoint supt. and engr. Avg. water production 2.79 mgd. Pptn. 39.4″, normal 41.7″. Mains 81.2 mi., gate valves 872, services 4041, public hydrants 230. Fixed assets $2,145,102, total assets $2,211,885, long-term debt $431,500, depn. reserve $613,827, funded debt retired through surplus $668,500, earned surplus $380,777. Water revenue $137,305, operating expense $99,243 (including $37,936 depn.), net operating

(Continued on page 50)

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Limitorque operates by the "push of a button" from either remote or nearby control panel . . . prevents damage to stem, seat, disc, gate or plug, because Torque Seating Switch limits the torque and thereby shuts off the motor before trouble can occur . . . actuated by any available power source . . . fits all types of valves. LimiTorque may be obtained through valve manufacturers.

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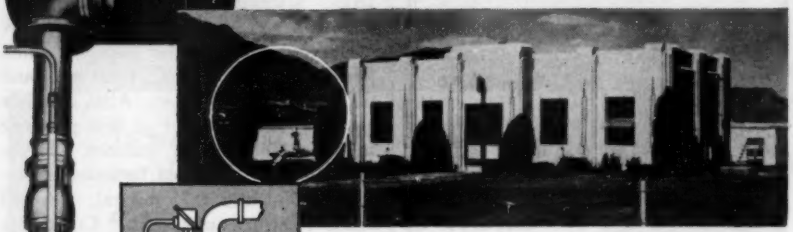

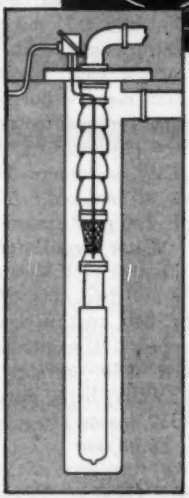

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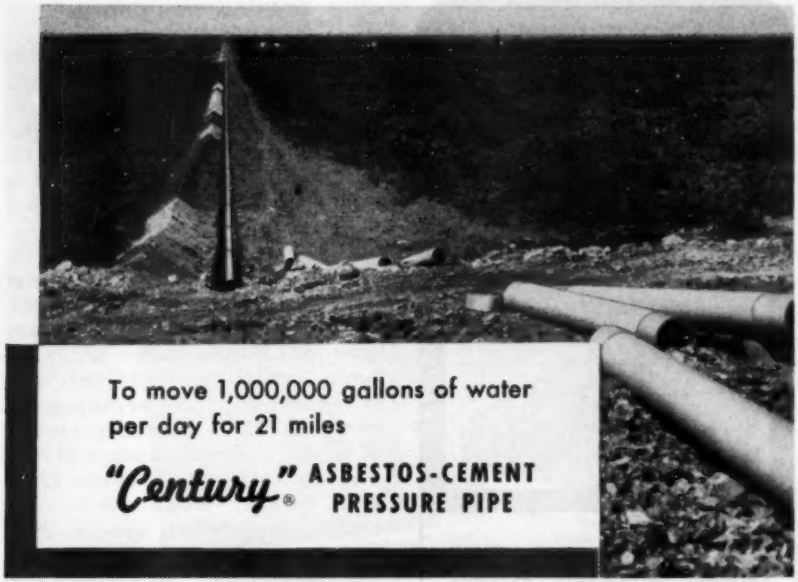
(*Continued from page 48*)

revenue $38,061, other income $1686, interest $16,289, bonds retired $25,000, net loss closed to surplus $1542.—*R. E. Thompson.*

Kalamazoo (Mich.) Light and Water Utilities. Annual Report (1950). Municipally owned since inception in 1843. Metering adopted in '94. Supply from 35 wells, 8 pump. stations delivering directly to mains against pressure of 7-mil.gal. reservoir and 0.52-mil.gal. standpipe. Also, 3 minor stations deliver water at low pressure to 1 or more major stations. High-pressure dist. supplied by booster station, 0.35- and 0.75-mil.gal. elevated tanks floating on system. Customers billed for service installations but maint. and repairs borne by utility. All income derived from water rates and utility pays to city equiv. of all taxes. City customers 13,950, township 3322, all metered. Avg. pumpage 9.67 mgd., 136 gpcd., max. 18.35. Pop. 70,975. Water acctd. for by meters 93.5%, another 1.15% used through fountains and hydrants. Gal. pumped per kwhr. 846, cost of power per 1000 gal. pumped 1.97¢, per kwhr. 1.67¢. New well field, ultimate capac. 6.9 mgd. (12 wells) being developed. Hydrants 1339, mains 216 mi., gates 2558. —*R. E. Thompson*

Concord (N.C.) Water Works. Short History (1950). First supply from spring—privately owned. Bought by town in 1900 and artesian wells drilled at spring site. By '11, wells inadequate and 1-mgd. coagulation (alum and soda ash) and filter plant built to treat Cold Water Creek water; enlarged successively to 2, 3 and 4 mgd. Lake Concord (yield 2.5 mgd.) built as reserve supply in '26; water delivered by natural water course to Cold Water Creek pumping station. New lake (1102 mil.gal.) on main stream of Cold Water Creek created

(*Continued on page 52*)



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Fast, easy laying means real savings on installation costs!

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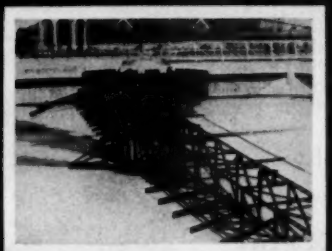

At a midwestern city, ERP cathodic protection systems have been controlling corrosion in large diameter clarifiers for several years. A recent inspection showed that "about 95% of the red lead undercoat was intact and—no pitting was taking place even at weld seams and bolt and rivet heads." Following this inspection, a neighboring city ordered ERP systems for both its clarifiers and flocculators.

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(Continued from page 50)

by constr., 5 mi. from town, of Lake Fisher Dam in '46, yield 9 mgd. Watershed 20 sq.mi., pptn. 48". In '50, pop. 16,740, served 22,048. Avg. consumption 3.35 mgd., max. 4.68. New 6-mgd. Hillgrove Filter Plant in operation. Clear water storage now 5 mil.gal.—*R. E. Thompson.*

Honolulu (Hawaii) Board of Water Supply. Annual Report (1949–50). In '50, total assets $19,110,018, utility plant $24,250,419, depn. $7,179,789, bonds outstanding $7,142,088 (decrease $372,699), debt service requirement $582,573. Operating revenue $2,635,649, operating expenses $1,758,249, depn. $483,486, net income $239,781. Services 33,475 (99.9% metered), mains 398 mi., hydrants 2890. Consumption 34.8 mgd. Public supply dates back to 1848; early history outlined. Artesian supply developed 1879–80. Rainfall 92.5% of normal but water levels in 5 artesian areas well maintd. As increased costs due to rapid expansion and inflation not offset by increased revenue, rates increased effective Feb. '51. Pop. declined to 245,523 (222,000 supplied) and despite record increase in services of 1656, water sold decreased 415 mil. gal. Delinquent accts. ('50) $31,281, uncollectable $1113 (118 accounts), biennium total $1800 or 0.034% of billing. Law of '29 forbids free water. Under 5 contracts predating law, 5.68 mil.gal. supplied in '50. Chloride content did not vary markedly but 10-yr. record indicates gradual salt encroachment in several wells. Since '24, 73 wells sealed as part of conservation program. There are 83 artesian wells and 23 inactive wells within city. No new wells since '46. Investigation being made of high-level artesian water body in Kalihi Valley. Underground sources not critically short at present but Honolulu aquifer cannot be considered source of increased sup-

(Continued on page 54)

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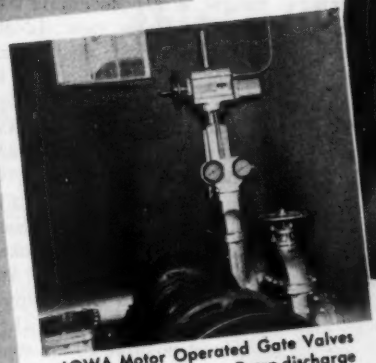

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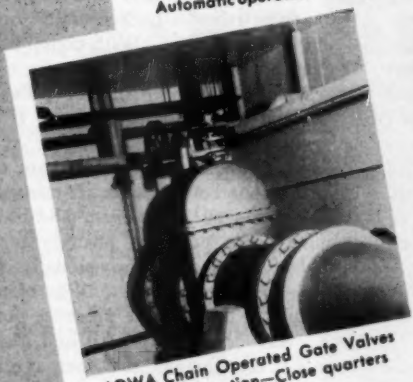

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(*Continued from page 52*)

ply required by expanded pop. of future. Most feasible and economical new sources several streams in Honolulu and artesian areas of Pearl Harbor and Moanalua. Use of surface waters seems inevitable, despite opposition. Rising land values rendering purchase of essential forest reserves more difficult. Daily mean supplied from underground sources by primary pumping stations 33.81 and 32.30 mgd. in '49 and '50, resp. Of this, 11.99 and 9.23 mgd. from Halawa underground station (Pearl Harbor artesian area). Addnl. daily private draft from 5 city artesian areas by private owners and govtl. agencies avgd. 9.9 and 9.1 mgd., resp., while draft by military was 11.6 and 11.8, resp. Unacctd. for water includes fire fighting, street washing, etc., 10.6 and 11.4%. There are 3 steam-powered stations drawing water from 25 artesian wells, 240′–636′ deep, 3 unattended elec. underground stations drawing water from horizontal collection tunnels near sea level, and 18 booster stations. Water produced by tunnels and springs of mountain gravity system avgd. 2.06 and 2.5 mgd. (7% of supply) in 2 yr., resp. All major distr. reservoirs and 24 of 31 (total capac. 22.06 mil.gal.) are concrete. System divided into 3 principal zones, el. from sea level to 1000′. Water supplied met U.S.P.H.S. standards, chem. and bact. In '49 and '50, resp., 0.81 and 0.96% of distr. system samples contained coliforms in 10 ml., while 0.29 and 0.43% of samples gave 3 or more positives. Mineral anal. given. Of 7 mountain gravity sources, 6 regularly chlorinated to give residual not less than 0.15 ppm., 20-min. contact. Rest not regularly chlorinated. All stations equipped with chlorine feeders for emergency use. New mains flushed at 7 fps., chlorinated 100–150 ppm. 24 hr., flushed and tested bacteriologically. During repairs, mains kept clean by cracking valves on either side and all pipe and fittings cleaned and sprayed with 2% NaOCl, followed by flushing. Asbestos rope substituted for jute in c-i. pipe joints. Per capita Consumption 157 gpcd., cost of water $138.40 per mil.gal. ('50), including fixed charges $180.95. Rates, new: 12–30¢ per 1000 gal., plus service charge varying from $1 per mo. for ¾″ meter to $100 for 12″. Mean rainfall, Lower Luakaha, Nuuanu Valley 135″. Avg. cost of operating motor vehicles 13.6¢ per mi. Appended is paper by J. M. Downer and H. M. Kawano entitled, "Bact. Comparison of Water Samples from Jute and Asbestos-Packed Mains." During '46–50, from 408 and 382 samples from new and repaired mains, resp., packed with jute, 23.5 and 14.6% coliform-positive 10-ml. tubes obtained. In '47–50, of 195 and 172 samples, resp., from asbestos-packed mains, only 8 and 0.8% positive. With const. flow through mains, coliforms usually disappear in 9–14 days. Improper flushing usual cause of pos. tests from asbestos-jointed mains: flushing at 7 fps. very important. Predominant organisms found after main disinfection are *A. aerogenes, A. cloacae* and those causing false presence positive tests. *Citrobacter* and others occasionally isolated. During period, 32.4% of all tubes planted were false presence positive. *Aerobe B. polymyxa* and *anaerobe Cl. viscifaciens,* or other species of genus *Clostridium,* most commonly found in false presence positive tubes. On rare occasions, *anaerobes* produce gas in B.G.B. *B. polymyxa* produces very small red colonies without metallic sheen on E.M.B. 7 references.—*R. E. Thompson.*

Dartmouth (Nova Scotia). Annual Report (1949). Gross surplus $51,557, 6.08% on depreciated value $348,403. Rates adopted in '47 designed to provide 6% return. Reve-

(*Continued on page 56*)

40 Years of Protection

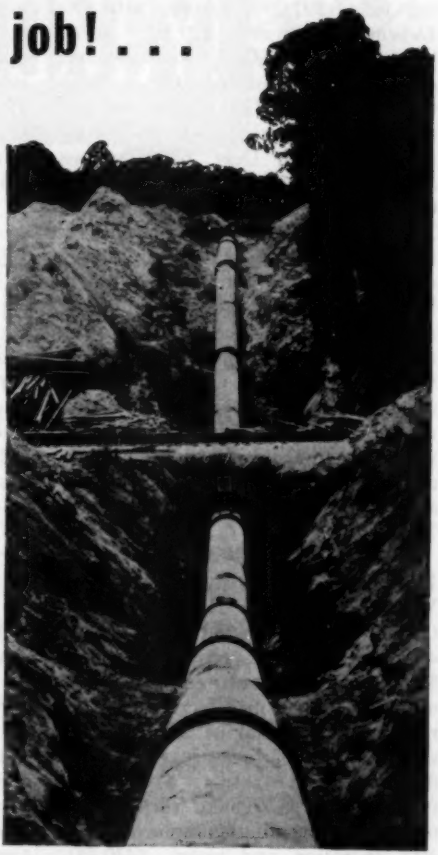
earned Koppers Bitumastic this job! . . .

In 1948—when the city of Springfield, Mass., met increasing demands for water with 26,000 feet of new 48-inch line — Koppers Bitumastic® 70-B Enamel was specified as an interior and exterior protective coating. With good reason, too, for Springfield engineers had first-hand knowledge of the long-lasting protection of Koppers Bitumastic.

In 1909, when Springfield's Westfield Little River System was started, seven miles of 42-inch line were coated with Koppers Bitumastic. For 40 years, the Bitumastic Coating has kept flow capacity high and guarded the line against corrosion. Other lines, laid in 1929 and 1943, also are protected by Bitumastic.

Inside the pipe, the glass-smooth, high-gloss surface of Koppers Bitumastic Enamel forms a barrier against tuberculation, rust and corrosion. Bitumastic keeps water from touching the underlying steel pipe surfaces . . . protects against the corrosive action of soil chemicals . . . has high electrical resistance. And it won't deteriorate with age.

If you're planning a water or sewage line, turn the coating job over to engineers of Koppers Contract Department. They'll handle it from start to finish, assuring long-lasting protection for the project. Write for complete information on Koppers Contract Service.



Springfield's new 48-inch line is shown crossing beneath railroad tracks through 72-inch pipe placed in an open cut. The new steel line, like others in the Springfield system, is protected with Koppers Bitumastic Enamel.

KOPPERS BITUMASTIC ENAMELS

KOPPERS COMPANY, INC., Dept. 905T Pittsburgh 19, Pa.

(*Continued from page 54*)

nue $125,150, including $14,783 from flat rates and $71,124 from metered rates. Expenditures $127,785, including debt charges $25,193 and grant to town $29,000. Net loss $2635. Capital assets $1,024,480, in addn. to sinking funds $91,099; surplus $468,846. Debentures retired $29,500, serial bonds issued $46,000. Improvements during war yr. cost $265,000, of which town share $168,750. Latter reduced to $126,268 during '44–'48. New agreement with Dept. of Munitions and Supply reduced balance to $100,000 and debentures issued for that amt. Mains 29.1 mi. Complete metering effected during yr. Pitometer survey revealed leakage totaling 0.25 mgd. Survey made to det. possibility of extending service to county areas. All extensions must yield return of at least 8% on capital cost. Consumption 607 mil.gal. Survey of watershed of Lamont and Topsail Lake authorized with view to acquiring sufficient property to protect supply for all time: 40 acres acquired during yr.—*R. E. Thompson.*

Little Rock (Ark.) Municipal Water Works. Annual Report (1950). Capital expenditure during yr. $458,444: during 15-yr. city management $3,184,275, financed entirely from earnings without debt increase. Rates reduced twice, total of 22%. Fixed assets $9,689,093, reserve funds, $1,026,132, total assets $11,255,514, funded debt $5,370,000, surplus $4,675,085. Operating revenue $1,010,400, operation and maint. $430,441, net operating income $579,959, fixed charges $221,167, net income $390,431, bonds retired $116,000. Avg. cost to consumers reduced from 42.3¢ to 33.3¢ per 1000 gal. since '36, avg. monthly domestic bill from $1.84 to $1.58. Pop. of city 105,105, served 159,070. Watershed tributary to Lake Winona (1240 acres, 13.5 bil.gal.), impounded by Alum Fork Dam, 43 sq.mi., almost wholly in Ouachita National Forest, uninhabited and covered with pine forest. Auxiliary impounding reservoir 20 acres area and 92 mil.gal. usable storage. Rainfall 63″,. 14.5″ more than normal. To control growth in 33-mi., 39″, gravity supply line, 12 ppm. chlorine introduced for 1 hr. at weekly intervals. Avg. water filtered 13.2 mgd. Capac. new plant 16 mgd., old plant 7. Settling basin equipped with Dorr flocculator, detention period 4.6 hr. Fluoridation to be commenced in '51. Mains 330 mi., valves 3094, hydrants 1390 (per mi. main 4.2, per 1000 pop. 13.1, spacing 1252′, rental $23.33 city, $35 Cammack Village), meters 28,606. National Board of Fire Underwriters Grade 3 in '47: greatly improved since. Chem. cost per mil.gal.: alum $1.27, lime $0.41, Cl $0.62, NH_3 $0.14, Calgon $1.09, soda ash $0.02, total $3.56. Avg. turbidity, raw 14 ppm., settled 6, hardness 20, pH raw 6.5 and effluent 8.3, color raw 35 and effluent O, effluent T.O. 6.8, effluent residual Cl 0.41, coliform index per 100 ml. raw 17.8 and effluent 0.058.—*R. E. Thompson.*

Wyandotte (Mich.) Water Dept. Annual Report (1950). Operating revenue $198,355, operating expense $136,074, depn. $41,291, interest $5761, net income $19,547. Fixed assets $2,531,729, depn. $923,501, sinking fund $28,919, bonds outstanding $118,919, book value $1,643,661. Mains 93 mi., valves 965, hydrants 757, meters 9432. Capacs.: filters 10 mgd. (10 units), underground storage 1.4 mil.gal., elevated tank 0.5 mil.gal., low service pumps 15 mgd., high service 14.8. Pop. 36,666, investment per capita served $69.04, per capita operating revenue $5.40, net per capita operating revenue $0.63. Consumption: 1631 mil.gal., 121.8 gpcd., max. day 6 mil.gal. Costs per 1000 gal.: pumping

(*Continued on page 58*)

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CALMET WATER METERS

MADE BY WELL MACHINERY & SUPPLY CO., INC.—FORT WORTH, TEXAS

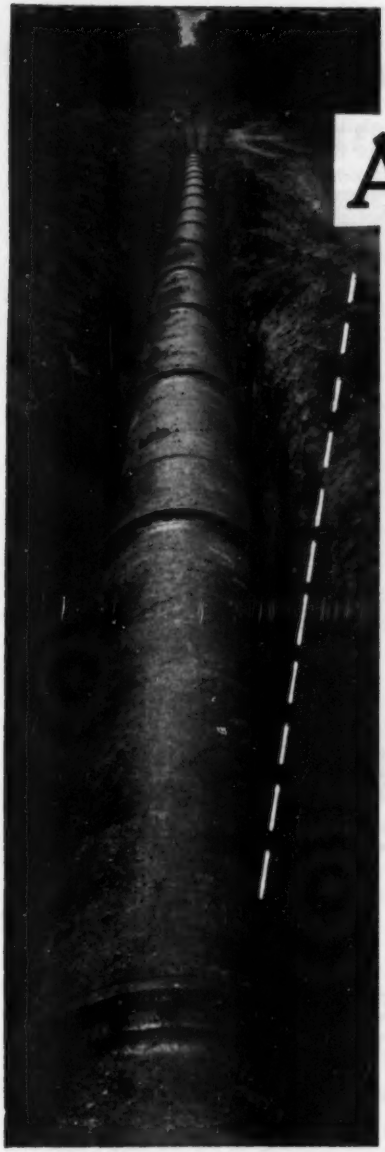
(*Continued from page 56*)

1.65¢, purif. 3.10¢, distr. 3.42¢, general 2.57¢, total 10.73¢. Revenue per 1000 gal. 12.16¢, net 1.43¢. Plant extended by adding 4 filters and new 42″ intake installed, improved qual. of raw water reducing costs. Fluoridation, using sodium silicofluoride, approved. Mineral anal. included. Total hardness 115 ppm., dissolved solids 140. Fire protection charge to city $1 per yr. Distr. losses 17.8% of total production.—*R. E. Thompson.*

Long Beach (Calif.) Water Dept. Annual Report (July 1, '49–June 30, '50). Estd. pop. 255,000. Operated by Board of Water Comrs. (5), appointed by city manager, subject to approval of city council. Water sales $2,218,759, total revenue $2,270,882, operating expense $1,197,489, depn. $258,868, bond interest $181,533, bond redemption $105,000 leaving net earnings $527,992. Expansion, financed from $6,400,000 bond issue, 50% completed. Largest item 40-mil.gal. J. Will Johnson Res. (12 steel tanks) on Dominguez Hill, el. 170′, same as existing Alamitos Res. Unique distr. reservoir system consists of multiple covered steel tanks at elevated sites, each contg. approx. 3.3 mil.gal. and designed to resist earthquakes and ground subsidence. Details included of design and constr. of Johnson tanks, each 132′ diam. and 34′ 9″ high, erected on 1′ sand mat impregnated with road oil at 350°F. After assembly, bottom and first ring jacked up for completion of bottom watertight seal weld and application of coal tar enamel; then lowered into position, upper courses welded into position, roof girders and rafters erected, and covering effected with tongue-and-groove redwood sheeting and asphaltic roofing. Inner surface coated with coal tar enamel and outer with red lead and aluminum paint. Cost substantially less than estd. $1,300,000. Water pumped from wells 58.3%, purchased from Metropolitan Water District 41.7%. Consumption 17–47 mgd., unacctd. for 4.62%. Metered gpcd. 112.8, incl. water unacctd. for 118.9. Pptn. 9.4″, 5.3″ less than 15-yr. avg. Level of underground waters of coastal plain continued to drop. New 25-mgd. treatment plant, financed from earnings, 80% completed. Mains 593 mi., valves 12,972, hydrants 3503, meters 57,840. Capital assets $16,942,630, depn. reserve $3,943,980, total assets $21,258,308, bonded debt $7,515,000, equity, including earned surplus, $13,460,140. Operating cost per 1000 cu.ft. sold 1.201¢, bond retirement 0.077¢, revenue 1.626¢. Rates per 100 cu.ft. 5–23¢ in city, 8–26¢ in county, min. monthly rate $1.25 and $3, resp., for ⅝″ and larger service.—*R. E. Thompson.*

Louisville (Kan.) Water Co. Annual Report (1950). Organized in 1854 at original cost $829,456: no addnl. required from city. Now debt free. Pop. 450,000. Owned by city. Supply from Ohio R. Total revenue $3,024,246, operation $1,490,933, retirement $374,040, interest $9,427, total expense $1,874,720, net income $1,149,527, dividend $850,000 (to city), transferred to surplus $299,527. Complete electrification of system near completion. During first 7½ mo., hardness of delivered water 75–95 ppm., during remainder of yr., partial softening only because of insufficient supply of soda ash. Avg. production 64 mgd., max. day 77.2, max. hrly. rate 132. Transmission main pitometer survey indicated need of cleaning. After annexation of large area, 1 water company purchased and negotiations begun to acquire others. Riverside Station pumping cost $8.02 per mil.gal., $4.26 per mil.gal. raised 100′, Crescent Hill Station $10.32 and $6.55, resp. Purif. cost $13.96 per mil.gal., of which $7.65 for chem. Filter plant output 59.5

(*Continued on page 60*)



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As America's largest individual cast iron pipe foundry, ACIPCO manufactures a complete line of cast iron pipe and fittings in diameters from 3" to 48", inclusive. The pipe which is made by the Mono-Cast centrifugal process is equipped with any of a wide variety of joints including Bell and Spigot, Doublex Simplex, Molox Ball and Socket, Roll-On-Rubber Ring, Screw-Gland, and Flanged. All ACIPCO pipe is manufactured under close control to meet nationally recognized standard specifications.

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(*Continued from page 58*)

mgd., avg. filter run 53–62 hr., wash water 1.68%, avg. bacterial removal (37°C) 99.9%, *B. coli* 99.99%, proportion softened 76%, suspended matter removed 14,276 tons. South Res. cleaned: 15,000 cu.yd. removed, 13¢ per yd. Prechlorination employed 10 mo., activated carbon used intermittently, ClO_2 for phenolic tastes. Avg. chem. dosages, lb. per mil.gal. treated: alum 152.9, lime 238.7, prechlorination chlorine 26.7, postchlorination chlorine 4.3, ammonium sulfate 4, soda ash 122.5, carbon 19.3, sodium aluminate 25.1, carbon dioxide 21.8, $NaClO_2$ 2.2. Avg. turbidity reduced from 155 ppm. to 0, total solids 300 to 166, hardness 115 to 97, taste 3.5 to 1, odor 3.2 to 1.2, bacteria 3658 to 1.92, gas formers per 100 cc. 6067 to 1.3, *B. coli* per 100 cc. 4982 to 0.08, pH increased from 7.4 to 9.0. Avg. residual chlorine in delivered water 0.48 ppm. Purif. plant includes 2 sedimentation basins, total capac. 106 mil.gal.; coagulation basins; clarifiers; and 26 rapid sand filters, some 3 and some 6 mgd. capac., total 120 mgd. Filtered water storage 26 mil.gal., Cardinal Hill Res. 30, elevated tanks (2) 1.75. Mains 816 mi., pressure 45–100 psi.; valves 11,306; services 97,416, active 90,469; 100% metered; hydrants 3998. Avg. consumption 59.49 mgd., 132 gpcd., 85.3% acctd. for by meters. Revenue per 1000 gal. 13.98¢, operating expenses 8.59¢, net operating income 5.39¢. Meter readings per man per day 198. Delinquent shutoffs 557. Fixed capital $26,816,081, bonds retired $404,000 (all), total assets $27,590,549.—*R. E. Thompson.*

Detroit (Mich.) Dept. of Water Supply. Annual Report (Year Ended June 30, '50). Plant and equip. $145,208,697, total assets $181,508,188, bonds outstanding $58,533,000, reserves $51,738,095, equity $69,384,507. Operating revenue $13,304,228, operating expenses, including depn., $8,134,694; net operating income $5,169,533; net income $3,772,303. Complaints: low pressure 1589, turbid water 828, taste and odor 55. Revenue-producing production 87.6%. Services 371,788, meters 365,085, gate valves 30,321. Pop. served 2,497,371, with 658,854 suburban (38 municipalities and 3 institutions). Avg. production 373 mgd., max. 578, approx. 50% each by Water Works Park and Springwells Stations: 151 gpcd. Heat rate of Springwells Power Plant 16,823 btu. per net generated kwhr., heat rate of station 15,023 btu. per water hp.hr., overall thermal efficiency 16.95%. Coliform M.P.N. raw water 364, max. 46,000. At Water Works Park Plant, avg. turbidity 20 ppm., max. 190, alum dosage 6–38 ppm., avg. 12. Turbidity removed 0.6 ppm. per ppm. Avg. prechlorination dosage 0.94 ppm., final 0.16; combined dosage range 0.84–3.06 ppm. Coliforms absent from 21,900 10-ml. portions tap water at plant lab. and all 4985 distr. system samples met U.S.P.H.S. stds. Of 8760 hrly. samples raw water treated with marginal chlorine dosages, 304 developed chem.-medicinal taste. Effluent always taste free. Continuous 24-hr. lab. control for past 25 yr. At Springwells Plant, avg. prechlorination dosage 1.08 ppm., somewhat greater than Water Works Park because of longer contact in raw water tunnel. Water qual. complaints: taste and odor 68, all unjustified; turbidity 758, chief cause hydrant operation; sickness 2, unjustified. New mains chlorinated and sampled before release for service. Ten widely scattered points in distr. system sampled weekly. Chlorine demand of raw water found to be normally function of albumin nitrogen content. Filter operation data, Water Works Park and Springwells avg. resp.: wash water 3.0 and 7.3%, runs 30 and 31 hr. (min. 23 and 24), rate 172 and 161

(*Continued on page 62*)

THE FIRST MECHANICAL JOINT TAPPING SLEEVE AND VALVE

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A new all Mechanical Joint Tapping Sleeve and Valve, installed quickly and easily even by untrained workmen. The only installation equipment necessary is a 10" ratchet wrench and a standard open end wrench.

There are no joints to pour or caulk.

Installation can be made in wet trenches in any kind of weather.

The "Stuffing Box" type joints require no cutting or scarfing of rubber gaskets on job.

Assemble Sleeve on main—attach the Valve, the installation is complete, ready for tapping and the joints are permanently bottle-tight.

32

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FIRE HYDRANTS
INSERTING VALVES
TAPPING SLEEVES AND VALVES
WATER SERVICE BRASS GOODS

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INDICATOR POSTS
TAPPING MACHINES
INSERTING MACHINES
PIPE CUTTING MACHINES
CORPORATION TAPPING MACHINES

(*Continued from page 60*)

mgd. (max. 203 and 191), applied water turbidity 9 and 8 ppm. (max. 15 and 12), effluent turbidity 0.1 and 0.3 (max. 0.2 and 0.4), effluent t.o. 1 (both), residual chlorine applied water 0.41 and 0.35 ppm., filtered 0.34 and 0.31, effluent 0.46 and 0.49, pH tap water 7.6 and 7.5. Raw water tunnel to Northeast Station under constr., general plant layout decided and some pumping plant contracts let. Purif. plant data, Water Works Park and Springwells, resp.: avg. retention coagulation and sedimentation 2 and 3 hr., filters 80 and 68, rated capac. 320 and 272 mgd. Rates, city and suburban, resp., 62–92¢ and 65–97¢ per 1000 cu.ft., monthly service charge 24¢ and 50¢ for ¾" or larger meter, min. bill $1.64 and $2.47 per quarter. Gross operating revenue per capita $5.37, per revenue account $36.25, per mi. distr. pipe $2524.29, per mil.gal. $97.76. Gross revenue per 1000 cu.ft. 89¢, operation and maint. 32.5¢, interest and depn. 32.7¢, total cost 65.2¢, unappropriated net income 23.8¢.—*R. E. Thompson.*

Greater Winnipeg (Man.) Water Dist. Annual Report (1950). Supplies 333,000 in Winnipeg and 8 adjoining municipalities, total area 55.3 sq.mi., with water from Shoal Lake and Lake of the Woods, 96.5 mi. away. First supply of city, from Assiniboine R. unsatisfactory. Private company purchased in 1899 and wells substituted for river water. In '01, lime-soda softening plant, first of kind on continent, installed. Dist. incorporated in '13 and permission obtained from Intl. Joint Com. to divert max. of 100 mgd. from Shoal Lake area of latter 107 sq.mi., of Lake of the Woods 1400 sq.mi., drainage area 27,700 sq.mi., el. of intake 290′ above Winnipeg reservoir. Project completed in '19. Virtually no settlement on watershed. Water not filtered. Treated with NH_3 and chlorine (1:4) to maintain 0.4 ppm. residual. $CuSO_4$ and free residual chlorination employed in summer to combat algae tastes and odors. Standard gauge railway (110 mi.), built to facilitate aqueduct constr., continued in service. Main section of aqueduct 85 mgd. capac. Interest and sinking fund from annual rate levied on land plus part of bulk water charge of 5¢ per 1000 gal. made to each municipality. Only 3 of latter have pumping plants, others purchase pressure. Each has representative on Admin. Board. Total mains 554 mi., services 76,091. Booster station with 3 20-mgd. units installed, increasing possible supply to Winnipeg pumping stations 42.5 mgd. Gross debt $13,927,113, sinking fund $7,313,921, total assets $25,766,008. Net revenue after provision for interest and sinking fund $75,898. Consumption 9203 mil. gal., 76 gpcd.—*R. E. Thompson.*

Los Angeles (Calif.) Board of Water and Power Comrs. Annual Report (Year Ending June 30, '50). Pop. increased from 1,504,277 in '40 to 1,957,692 in '50. Owens-Mono basins provided 74.1% of supply, Los Angeles R. 22.7% (including local sources), Colorado R. through Metropolitan Water Dist. aqueduct 3.2%: in future, greater dependence upon latter, other supplies used approx. to capac. Available supply ample for double present pop. Prelim. work begun on new regulating reservoir and 10-mi. 66" pipeline, 171-mgd. capac., to transport Colorado R. water to Lower Hollywood Res. Consumption 347 mgd., domestic 288, peak day 560, max. hr. 35.4 mil.gal., avg. use 154 gpcd. Meters 402,097 (largest 100% metered water utility in U. S.). Baldwin Res., 19 acres area and 293 mil. gal. capac., approaching completion. Internal aqueduct loop being developed which will make possible supply from

(*Continued on page 64*)

portraits of protection

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Note: When the correct NO-OX-ID is applied to the metal surface of a water tank, corrosion is stopped . . . with a single coat. Dearborn also supplies long-lasting, good-looking aluminum protective coating for tank exteriors.

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(*Continued from page 62*)

any source to any point of 453-sq.mi. supply area. Total storage 402,035 acre-ft., trunk lines and conduits 32.4 mi., distr. lines 4760 mi. (vol. 143 mil. gal.), main gate valves 66,514, hydrants 26,319. Current operations paid entirely from revenue, expansion from revenue and revenue bonds. Gross income $19,060,217, operating expenses $10,611,645, net income after interest and depn. $3,147,492: of latter, $891,000 to city general fund and remainder available for bond retirement and improvements. Plant and equip. $220,762,098, bonds outstanding $57,710,540, depn. reserve $58,567,584, total assets $242,667,045, equity $121,950,019. Avg. billing price per 100 cu.ft. 15.23¢ residential, 11.17c all classes.—*R. E. Thompson.*

Fort Worth (Tex.) City Water Dept. Annual Report (Oct. 1, '49–Sep. 30, '50). First municipally owned plant 1892, supply from Clear Fork of Trinity R., supplemented by 13 artesian wells. In '14, Lake Worth (28,660 acre-ft.) created on West Fork of Trinity R., followed by Lake Bridgeport (292,000 acre-ft.) in '32 and Eagle Mountain Lake (211,000 acre-ft.) in '34, both above Lake Worth on West Fork watershed. Yield during drought 150 mgd. Dam under constr. on Clear Fork to form Benbrook Lake (89,000 acre-ft.). Two conduits (36–48 and 60″, resp.) have capac. 70 mgd. Treatment plant includes aeration facilities, not used during summer peak, chem. mixing and sedimentation basins, 12 1.25- and 16 x 2-mgd. rapid sand filters capable of being overloaded to 66 mgd., chlorination and 5 clear wells, combined capac. 10 mil.gal. Total elevated storage 14.5 mil.gal. Mains 785 mi., hydrants 3799 (5 per mi.), meters 72,817. Delinquent cutoffs 4435. Hydrants spaced to supply all insurable risks within 500′ air line distance from hydrant by main with min. 6″ diam. Consumption 10,221 mil.gal., 101 gpcd. Water unacctd. for 10.75%. Water filtered 28.5 mgd., max. 54.8. Cost of treatment per mil.gal. $7.72. Avg. alum dosage 12.48 ppm., hydrated lime 4.96 ppm., chlorine 1.35 ppm. Turbidity reduced from 25 to 0, bacteria per ml. 169 to 1 (max. 6), coliforms per 100 ml. 110 to 0. Avg. filter runs, 1.25 and 2 mgd. filters, resp., 53.3 and 51.3 hr., min. 7.7 and 11.8. Wash water rise per min. 19.1″ and 23.6, 1.25%. Avg. hardness 120 ppm., pH 7.9, turbidity applied water 10, residual chlorine 0.65 (max. 1.08). Typhoid death rate 0 for third successive yr. Coliform tests, distr. system: of 8125 10-ml. portions from 1625 samples, 269 presumed positive, 50 confirmed. Pop. served 278,000. Net water and sewerage debt $13,932,343. Total assets $27,364,725, surplus $11,517,520. No depn. acct. Operating revenue $3,237,387, operating expenses $1,164,554, bad debts $2,058, operating income $2,070,775, debt charges $480,824, net income $1,597,533.—*R. E. Thompson.*

Sacramento (Calif.) Div. of Water. Annual Report (1950). Operating revenue $889,578, operating expenses $419,368, bond interest $81,841, net operating revenue $388,369, net revenue $381,780, bond redemption $185,575, net profit $196,205, capital expenditures $98,391, net surplus $97,814. Depn. approx. $200,000, but no depn. sinking fund. Avg. pumpage 34.5 mgd., 247 gpcd., max. day 63.6. Sutterville Park Water System, 6 deep wells and distr. system of 83,535′ steel pipe, purchased for $121,000. Net surplus from this system first 6 mo. $10,370. Application for American R. water from new Folsom Res. made and negotiations under way for new filtration plant site. Ordinance creating water div. ('31) prohibits meters on

(*Continued on page 66*)

A hole in a joint no larger than the end of your little finger will, under 65 psi pressure, discharge more than 80,000 gpd.

Fix it once . . . Fix it for good

"Small" leaks cost you so much in gallonage . . . and repeated repairs cost you so much in dollars and cents . . . that the only practical repair is one that's *permanent*.

A permanent repair is certain every time when you put on a Dresser Bell-Joint Clamp. Clamping seals the joint with resilient rubber compound—provides a flexible repair to guard against future pipe movement, vibration and stresses which cause recalked joints to leak again and again.

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(*Continued from page 64*)

domestic services and provides that funds in surplus acct. exceeding 25% of total operating and maint. expenses of previous yr. may be transferred to general city fund. Zone 1 of system supplied with treated Sacramento R. water, Zone 2 with well water by both city and Southern Calif. Water Co., Zone 3, former Sutterville Park area, by wells. No master meters on well systems; production and cost data, therefore, for Zone 1 only. Estd. pop. served 146,100, of which 139,700 in Zone 1. Mains 353 mi., valves 5978, hydrants 2047, accts. metered 0.68%. Three elevated tanks, each 3-mil.gal. capac. Pretreatment works 80 mgd., filters 16 x 4-mgd. units, filtered water storage (2 basins) 14.5 mil.gal, low-lift pumps 130 mgd., high-lift 102. Power cost per mil.gal. $6.089, water pumped per kwhr. 1281 gal. Alum mfd. at plant, avg. dosage 1.0, max. 4. Avg., chlorine dosage 0.28 ppm., max. 0.7; avg. residual 0.07, max. 0.12. Wash water 1.6%. Turbidity reduced from 36 ppm. avg. (max. 750) to 0, avg. turbidity applied water 3 ppm., max. 22. Avg. hardness 56, max. 120; avg. pH 6.7; avg. dissolved solids 81.3 ppm. Bact. per cc. (37°C) reduced from 181 (max. 2700) to 0.09 (max. 2); *B. coli* index from 5.4 (max. 70) to 0. Cost of purif. $8.13 per mil.gal. Total cost to div. and consumer, resp., per mil.gal. $62.81 and $70.57; per consumer per yr. $19.90 and $22.35 (per capita $6.37).—*R. E. Thompson.*

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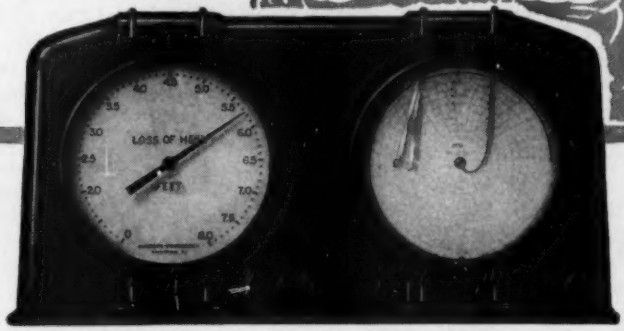
Aberdeen (Wash.) Water Dept. Income, Profit and Loss Statement (1950). Gross income $291,126, operating expense $190,546, operating income $102,064, interest $25,100, taxes $16,369, net income $60,595, profit (including other gains and losses) $67,765, appropriated from latter for bond redemption fund $56,010. Fixed assets $3,372,383, total credits $3,691,353, bonds outstanding $474,000, reserves $1,341,975, surplus $1,837,951.—*R. E. Thompson.*

Kenosha (Wis.) Water Dept. Annual Report (1950). Assets $4,102,092, depn. reserves $728,056, earned surplus $2,276,147, bonds outstanding $340,000. Operating revenue $411,776 (highest in history—rates increased); operating expenses, including depn. and taxes, $323,110; net operating revenue $88,666; total net income $91,646. City taxes $63,068, 15.3% of total operating revenue. Public fire protection charge $91,269, $84.74 per hydrant. Avg. cost to domestic consumers 13.3¢ per 100 cu. ft., 3.5¢ per customer per day. Avg. cost to commercial users 10.15¢ per 100 cu.ft., industrial 6.3¢. Lowest step of rate schedule 5¢. Water acctd. for by meters 92.2%, increase of 2.2%; of re-

(*Continued on page 68*)

KEEP A SHARP EYE ON FILTER OPERATION WITH BUILDERS GAUGES



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BUILDERS

(*Continued from page 66*)

mainder, 2.2% used for flushing mains and sewers and fire fighting. Avg. evapn. 8.88 lb. water per lb. coal fired, overall boiler and furnace eff. 75.5%, avg. steam cost 44.6¢ per 1000 psi. Mains 131 mi., pop. per mi. 413, hydrants 1077 (per mi. of pipe 8.2), live services 12,711. Pop. 54,360. Employees, 1 per 1360 persons served. Wash water 3.4%, avg. alum dosage 11.46 ppm.; NH_3, chlorine and activated carbon also used. Avg. turbidity reduced from 25 ppm. to 0. Residual chlorine 0.38 ppm., pH 7.6. Avg. consumption 7.36 mgd., 135 gpcd., max. 11.53 mgd. Avg. return per 100 cu.ft. billed 9.57¢. Operating expenses, excluding fixed charges, depn. and taxes, $4.06 per capita; $82.10 per mil.gal. pumped; 53.7% of gross income.—*R. E. Thompson.*

HEALTH AND HYGIENE

The Newburgh-Kingston Caries Fluorine Study. I. Dental Findings After Three Years of Water Fluoridation. D. B. Ast, S. B. Finn & Isabel McCaffrey. Am. J. Pub. Health, **40**:716 (June '50). Newburgh and Kingston are 2 towns approx. 30 mi. apart in N.Y., with pops. of approx. 30,000 each. Since May 1945, sodium fluoride has been added to Newburgh water supply to provide F content of 1:0 to 1:2 ppm., whereas Kingston's supply remains fluorine free. Article compares incidence of caries in permanent teeth of children 6–12 yr. in the towns during the 3 years after the first fluorine addition. At beginning of survey caries incidence in Newburgh was 21 per 100 erupted permanent teeth and at last survey was 14.8 per 100. Kingston figure remained practically const. at approx. 21 per 100 during the 3 years. At last examn. it was 21.3 per 100. Difference of 6.5 carious teeth per 100 represents reduction in caries incidence of approx. 30% in the F area. The greater part of the caries incidence in children aged 6–12 is acctd. for by caries of the first permanent molars. Much of article devoted to anals. of frequency of caries in those teeth. Newburgh children's caries incidence in the first molars at the end of the 3 years was 48.0 per 100 and in Kingston 58.7—reduction of approx. 18%. Reduction was more marked in upper molars (22%) than in lower molars (15%). Is only preliminary report and expected that 10–12 years will be required before firm conclusions can be reached on eff. and safety of water fluorination on these lines. Would be unwise to attach much importance to figures recorded in article. Do not indicate why 6–12 age groups chosen for anal. The first permanent molars of the children aged 10, 11 and 12 were practically all erupted in May 1945. They offered only posteruptive exposure to fluorine, whereas the first molars of the youngest children had both pre- and posteruptive exposure. If the anals. had been confined to children aged 6, 7 and 8 years, the Newburgh reductions might have been different from those recorded. In Table 3 of the article some figures strongly suggest the caries inhibition produced by fluorine is transient. At the last examn. the caries incidence per 100 first molars was:

Community	Ages—yr.		
	6–7	8–9	10–12
Newburgh	9.1	39.3	68.7
Kingston	19.8	52.5	78.7

At 8–9 years, caries incidence in Newburgh first molars was twice as great as in Kingston first molars at 6–7. Figures in the authors' Table 5 also suggest protection by fluorine is temporary.—*B.H.*

(*Continued on page 70*)

Now...Dallas Park Cities are pumping with Economy!

Portion of main pump room, Park Cities Water Treatment Project. Shown are 13 of the 22 Economy Pumps installed on this project.

In new Park Cities, Texas, water treatment plant

Economical operation over a period of years was a primary requisite of the pumps for Park Cities Water Treatment Project, Dallas. In selecting pumps, Powell & Powell, consulting engineers, drew up specifications which took into consideration cost of equipment, efficiency of each unit and efficiency of units operating in series, plus rigid structural requirements and refinements of mechanical detail. Under this very exacting evaluation formula, Economy Pumps, designed especially for water works service, supplied by the Lone Star Pump and Machinery Co., were selected on the Dallas County project.

View in University Park Booster Station, part of the Park Cities project. These Economy Pumps boost the pressure going to the overhead storage tank, located 5 miles from the treatment plant.

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(*Continued from page 68*)

Newburgh-Kingston Caries Fluorine Study III. Further Analysis of Dental Findings Including the Permanent and Deciduous Dentitions After Four Years of Water Fluoridation. DAVID B. AST, SIDNEY B. FINN, HELEN C. CHASE, Jour. Am. Dental Assn., **42**:2:188 (Feb. '51). In this third progress report, anal. of data on caries experience of deciduous and permanent teeth of approx. 3200 children 5–12 yr. old in Newburgh, N.Y. (1.0–1.2 ppm. fluorides added to drinking water since May 2, 1945); and among 3100 children of same age in Kingston, N.Y. (fluorides less than 0.1 ppm.). In fourth postfluoride yr. new low of 13.9 DMF (decayed-missing-filled) per 100 permanent teeth noted in 6–12-yr. group. This rate 32.5% less than 1944–45 base; Kingston rate for same age group remained same as 20.2 DMF. Newburgh rate showed greater reduction among younger children: 77.6% at 6, 55.5% at 7, and 42.1% at 8 yr. Number of caries-free first permanent molars increased at Newburgh from 58.9 to 76.9 per 100 molars among 6–9 age group. At Kingston rate remained same. Present trend in caries reduction at Newburgh "may ultimately lead to a decrease in dental caries problem to a point where present dental personnel and facilities may be able to control this almost universal disease."—*F. J. Maier*

Newburgh-Kingston Caries—Fluorine Study II. Pediatric Aspects—Preliminary Report. E. R. SCHLESINGER, D. E. OVERTON & HELEN C. CHASE. Am. J. Pub. Health, **40**:725 (June '50). Fluorine is such a potent element was felt desirable to investigate the possibility of toxic effects being produced even by such a low water concn. as the 1.2 ppm. used for Newburgh-Kingston caries study. Arrangements made for a research team to exam. at least 500 children in each of the 2 cities at time of fluorine introduction into Newburgh drinking water, and subsequently. At physical examn. special attention paid to: oiliness or dryness of skin, skin turgor, abnormal markings or brittleness of nails. Physical measurements included those of weight, standing and sitting height and head and chest circumference. Newburgh children examined subjected to haemoglobin estn., total leucocyte count, total erythrocyte count and urine analysis. X-rays taken of the right wrist and both knees annually. Small groups of Newburgh children have had special ophthalmic examn. with mapping of visual fields and detn. of transparency of cornea and lens. They have also received special otological examn., including audiometric testing. Study has disclosed no deleterious systemic effects from the fluorine ingestion. Whether cumulative effects of fluorine may be found later, remains to be determined. —*B.H.*

Fluorine in Foods. F. J. MCCLURE. Pub. Hlth. Rpt., **64**:1061 (1949). Tables compiled from the literature on the content of fluorine in ppm. in various animal tissues; fish, egg, milk, fruits, tea, cereals and cereal products, vegetables and wine. Was found that the fluorine content in soil or water has little or no effect on the content of fluorine in foods grown in them. Excluding drinking water, avg. diet appears to provide 0–2–0.3 mg. of fluorine per day. As it was shown that intake of addnl. fluorine in drinking water is beneficial to the development of teeth it is considered justifiable to add fluorine to the diet if water contains less than optimum fluorine content.—*W.P.A.*

The Brantford Fluorine Experiment—Interim Report After Five

(*Continued on page 72*)

In considering replacement vs. reconditioning of a 53 year old line carrying Water to Chula Vista and National City, Calif., the California Water and Telephone Company decided to recondition the line since replacement in addition to the tremendous cost would have meant disturbing many acres of valuable citrus and vegetable fields.

Reconditioning involved a thorough cleaning by National of over 15,000 feet of 24 inch line, after which the entire line was centrilined.

According to information received, the reconditioning has added at least 20 years more of useful life with a marked increase in the volume of water previously handled.

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(*Continued from page 70*)

Years of Water Fluoridation. W. L. HUTTON, B. W. LINSCOTT & D. B. WILLIAMS. Can. Journ. Pub. Health **42**:81 (Mar. '51). Sodium fluoride has been applied continuously to the Brantford, Ont., water supply since June 20, 1945. Original feed was 1.0 ppm. F, changed to 1.2 ppm. Feb. 15, 1949. Caries prevalence surveys of children using fluoridated water were made before fluoridation started and annually thereafter. At end of 5 yrs., DMF rates for permanent and deciduous teeth among 5, 6, and 7-yr.-old children declined 54, 43 and 45%, respectively. The proportions of Brantford school children having perfect teeth, 1944–1950:

Yr.	No. Pupils		
	Total	With perfect teeth	
			per cent
Prefluoridation			
1944–45	5,482	284	5.18
Postfluoridation			
1946	2,787	200	7.17
1947	2,751	254	9.23
1948	2,863	356	12.44
1949	2,870	398	13.86
1950	2,873	449	15.63

Sodium fluoride introduced into city water by small volumetric feeder. Originally sodium fluoride imported from U.S. but cost rose from 12.89 to 17.84¢/lb., causing purchase of Canadian material at 12.6¢/lb. In '49 fluoride cost $5030 for assumed population of 40,000 giving /cap. cost of 12.6¢/yr.—*F. J. Maier*

The Malicious Poisoning of Water Supplies and Its Detection. ROBERT A. GREENE & EDWARD L. BREAZEALE. Arizona Med., **5**:60 (1948). Possibility of malicious poisoning of water discussed. The probable toxic materials which might be used named and the concns. necessary to produce injurious effects given. Scheme of anal. suggested which, although not all inclusive, may be employed for detection or elimn. of more common poisons.—*P.H.E.A.*

Nitrate Poisoning of Infants by Contaminated Drinking Water. H. E. ROBERTSON & M. E. DRAYCOTT. Can. Pub. Health J., **40**:72 (1949). In 6 months, nitrate-contamd. drinking water was responsible for 10 cases of methemoglobinemia (2 fatal) in infants under 3 mo. old. Survey of waters of more than 2,000 wells in rural Saskatchewan showed 31.4% contained more than 10 ppm. of nitrates, 25.5 more than 20 ppm., 18.8% more than 50 ppm. and 5.3% more than 300 ppm. Nitrite seldom exceeded 1 ppm. Of the waters examd., 19.8% contained both high nitrate and coliform organisms. A measure of nitrate content is a measure of contamn. from animal and vegetable decay.—*C.A.*

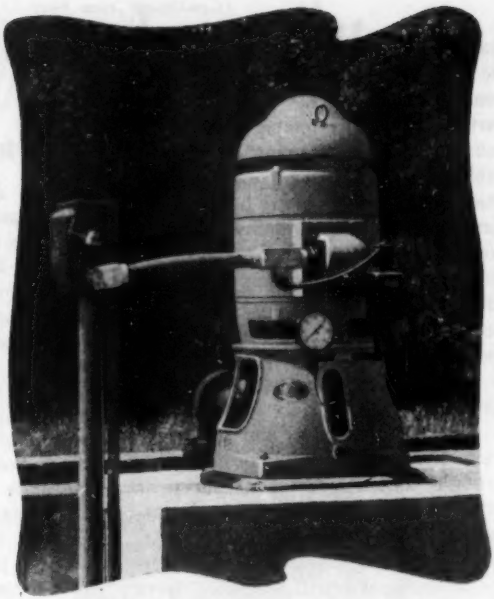
Nitrate Content in Well Waters. H. SIEMENS & C. MALLETT. Can. Pub. Health J., **41**:201 (1950). Repeated anals. of well waters showed marked fluctuation for short time. Since in one well the nitrate content rose from zero to 38 ppm. in little more than a month, worth of single neg. value is questioned. Some tests run in subzero weather when bact. action should be at a standstill gave nitrate levels of 60 ppm. Other factors influencing nitrate levels suggested.—*C.A.*

The Spread of Poliomyelitis by Public Water Supplies. E. F. W. MACKENZIE. Wtr. and Wtr. Eng. (Br.), **54**:227 (Dec. '50). Poliomyelitis received little notice in medical literature until approx. century ago. Scandina-

(*Continued on page 74*)

NEW CATALOG

—A new 52-page catalog on Layne Well Water Systems will be sent on request.



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(*Continued from page 72*)

vian races appear particularly susceptible and suffered many outbreaks at home and in U. S. Epidemics occurred mainly in temperate climates and in countries enjoying best std. of public health. During epidemic as much as 80% of pop. may be excreting virus. Transfer of poliomyelitis from group of respiratory diseases to excremental diseases and claims made that virus can exist long after discharge from human body necessitated complete reconsideration of possible routes by which it may be spread.. Is important to examine only case in favor of carriage by water and means of prevention. Possibility of infection through contamd. drinking must be accepted, but probability must be assessed against cost of prevention. Attempts to assess susceptibility of virus to conventional purif. processes were made on lab. scale in U.S. between '42 and '48. Further investigations performed. Results in keeping with lack of evidence of large scale transmission by purified public water. No evidence that virus ever distributed in public water in sufficient quant. to cause infection or that it is capable of surviving in such quant. after purification processes applied to board's water. Problem must be kept constantly under review.—*H. E. Babbitt.*

Is Poliomyelitis a Water-Borne Disease? G. v. BENEDEN. Bull. Centre belge Et. Document. Eaux, **1**:35 (1948). Possible rôle of wind and water in transmitting the polymyelitis virus to man discussed, and work on inactivation or removal of virus from water and sewage reviewed. The ultravirus, which may not be a living organim but part of cycle of virus anabolism, may persist in surface waters for long periods without being affected by flora of streams as are other pathogenic organisms. Possible to infect exptl. animals with poliomyelitis by inoculating with sediment from polluted water after centrifuging.—*W.P.A.*

DISTRIBUTION SYSTEMS

Ottawa Adds 750,000 Gallon Elevated Tank to Water System. E. N. ZIMMERMAN. Eng. Cont. Rec. (Can.), **64**:2:80 (Feb. '51). Pop. 193,495, mains 272 mi., hydrants 2361, avg. consumption 23.4 mgd. Supply from Ottawa R. through main pumping sta., 42-mgd. rapid sand filter plant and 6-mil.gal. clear water reservoir on Lemieux Island. Water delivered to system at 80 psi. by main sta. or flows by gravity to Queen St. Hydraulic station also operated at 80 psi. Slater St. High Pressure station operated only during serious fires, boosting pressure from 40–55 to 95 psi. in business dist. Carling Ave. station increased pressure to 75 psi. in area where new tank is located. Latter, of radial-cone bottom design, all welded, diam. 82′, height to bottom 125′, head range 25′, supported on 12 cylindrical columns, 48″ diam., with 8′ riser.—*R. E. Thompson*

Quebec Municipality Builds New Concrete Water Tanks. Eng. Cont. Rec., **64**:5:102 (May '51). Constr. of

(*Continued on page 76*)

Increased Supply for Springs Mills...

Through the clear well

Famous "Spring Maid" fabrics continue to be processed with the purest of water despite needs for sharply increased output. This 2½ million gallon per day addition was recently added to Roberts' initial filter plant at the Lancaster, South Carolina, Mill. Photo at upper left shows the nationally-known "Spring Maid" trademark as seen through several feet of water in the clear well.

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MECHANICAL EQUIPMENT BY ROBERTS FILTER MFG. CO. DARBY, PENNA.

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(*Continued from page 74*)

2 circular, prestressed concrete storage tanks in Ste. Therese described. Each tank 50′ diam., water depth 25′, capac. 300,000 gal. Radial thrust of dome roof balanced by prestressing of walls. Concrete permanently in compression in both directions under full load. Steel used approx. 20% of that for conventional design. Tanks completely buried, with 18″ earth cover on roofs.—*R. E. Thompson.*

Distribution System Practice. W. W. Inf. Exch.—Can. Sec. A.W.W.A., 7:C:4:51 (Feb. '51). Tabulation for Canadian municipalities of largest size main on which service connection is permitted. Length of mains owned in outside municipalities and pop. served thereby discussed. Types of joints and jointing materials used, and type of protection employed for street valves reported.—*R. E. Thompson.*

Waste Water Detection and Suppression. Wtr. and Wtr. Eng. (Br.), 55:100 (Mar. '51). Importance of detecting and preventing waste has always been recognized by board who have employed specially trained staff continuously for that work. Between '39 and '45 waste suppression experienced setback. When war ended it was clear Board might have difficulty meeting increasing legitimate demand for water unless increase could be offset by substantial leakage and waste reduction. In '39 there were 2,124 dist. controlled by 1,629 waste water meters. There are now 2,832 dist. and 1,760 meters. Deacon waste water meter system involves div. of area into large number of small waste dist., each of which can be supplied separately with water through single recording meter of special design. Rate of flow at different times can be detd. Meters are not run continuously. Particular attention given flow rate during early morning. Possible undue waste or leakage shown can be located within narrow limits by valve inspection which is made by running meter during early morning and shutting down each main supplied through it in turn at prearranged time. Probable loss can also be estimated. Information passed to waste inspectors who know amt. waste to be traced and where to look for it. Leak may be located by direct observation, by listening to sound of escaping water or with elec. instruments. During yr. ending Mar. 31, '50 there were 1.006 valve inspections which stopped 14.4 mgd. (Imp.) waste. Other inspections acctd. for 7.2 mgd. (Imp.) making total of 21.6. Min. night flow does not always represent solely water which is wasted or lost through leakage. Comparison of night flows over period will show if waste is increasing or decreasing.

(*Continued on page 78*)

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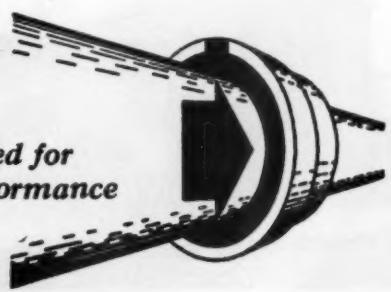

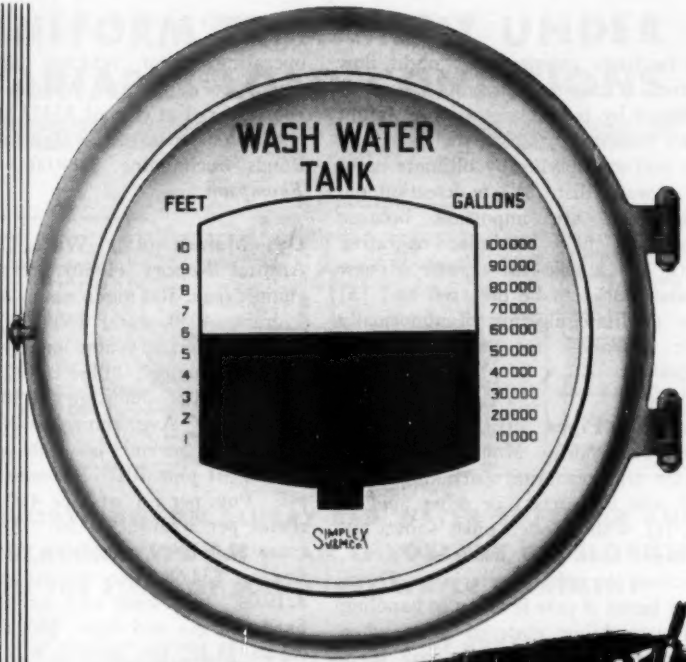

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SIMPLEX

VALVE AND METER COMPANY

(*Continued from page 76*)

To facilitate comparison, "night flow factor" is calcd. every mo. Amt. is obtained by taking avg. of min. night flows recorded on all waste water meters and multiplying by ultimate number of waste dist. Waste detection and suppression are important because they: [1] help minimize operating costs, [2] enable the constr. of new capital works to be deferred and [3] they facilitate meeting of abnormally high demands for water.—*H. E. Babbitt.*

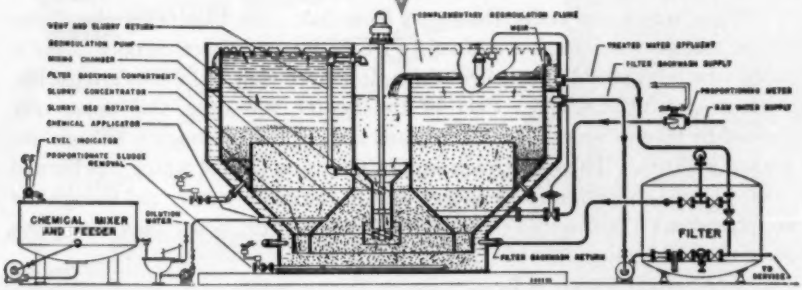
Wooden Pipes. LUCIO SUSMEL. Italia Forestale e. Mont., **6**:19 ('51). Water transportation (drinking, mineral, and industrial) or other acid or alk. liq. with wooden pipes shows advantages over pipes made of Fe, c.i., concrete, or other materials. Durability better if care is taken in handling and assembling material than when treatments with antiseptics are used. High lignin content (av. 30%, as in *Larix, Douglasia, Pinus,* and *Abies*) has a large protective action. The resistance of the pipes can be increased by impregnation and protection of surfaces with varnishes, waxes, paraffin, or bituminous resins. Decompn. of wood does not occur at pH 2 to approx. 10.—*C.A.*

ANNUAL REPORTS

Green Bay (Wis.) Water Dept. Annual Report (1950). Supply from 8 deep wells, chlorinated. Contract let for new well. Avg. cost per ft. of c.-i. mains laid: 2″, $2.40; 6″, $3.25; 8″, $4.60; 12″, $6.12. Avg. cost per ft. of ¾″ services: laid by dept. labor $1.39, by contract (trench and backfill) $1.34. Mi. of services 72, of mains 149. Max. pumpage 9 mgd., avg. 6.21, 117 gpcd. Recorded by meters 85.8%, used by fire dept. 0.009%, unaccounted for 13.8%. Avg. power cost 1.2¢ per kwhr. Cost of operating motor vehicles, excluding depn., 2.67¢ per mi. Meters 12,919; 786 repaired at cost of $3333.33, 25.8¢ per meter in service. Hydrants 856. Bonds outstanding $489,000.—*R. E. Thompson.*

Des Moines (Ia.) Water Works. Annual Report (1950). High lift pump capac. 100 mgd., mains 474 mi., hydrants 4030, water accounts 47,860, meters 47,655. Water metered 82% of water pumped, billed 80.8%. Pop. 194,523, avg. pumpage 20.16 mgd., 103.6 gpcd. Avg. return on 1000 gal. billed 28¢. Services per 1000 pop. 246, per mi. of pipe 101. Pressure 38–118 psi. Pop. per mi. of pipe 410. Main rental per hydrant $6.56. Gross income $1,611,820, per capita $8.29, per service $33.68, per mil.gal. pumped $219.04. Operating cost, exclusive of fixed charges and depn. $800,609, per capita $4.12, per service $16.73, per mil.gal. pumped $108.80, portion of gross income 49.67%. Interest 8.69% of gross income. Depn. $161,678, interest $140,029, sinking fund $282,889, net balance $226,614. Fixed assets $13,190,367, less depn. $3,069,978, indebtedness $3,191,000, reserves $645,456, total assets $11,291,355. Bonds and certificates retired during yr. $260,000. Avg. chem. dosages: lime 212, soda ash 28.6, alum 35.7 ppm., CO_2 154 lb. per mil.gal. (1.8 ppm.), Na polyphosphate 0.47, Cl 0.23 ppm. Avg. alky. reduced from 229 to 39 ppm., hardness from 290 to 83, Fe from 0.31 to 0.016 pH increased from 7.5 to 10.06, avg. residual Cl 0.024 ppm. Avg. 37° bacterial count at high lift sta. 0.26 per ml., tap water 0.59. No coliforms in daily samples from sta. and office tap. Of 1770 samples from distr. system, 28 produced gas in lactose broth and 4 in brilliant green bile. Delivered water free from turbidity, color, taste and odor.—*R. E. Thompson.*

UNIFORM TREATMENT UNDER VARIABLE LOAD CONDITIONS



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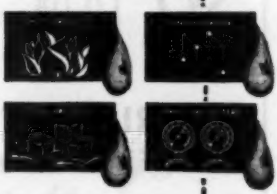
- Full utilization of slurry before removal.
- Quick, thorough mixing assured by application of chemicals to a relatively small volume of water.
- When filters are used in softening, an adequate supply of clear treated water backwashes the filters — independent of the softening process and without loss of water.
- Symmetry of reaction tank design.
- Full retention time always maintained, because there is no deposit build-up in the bottom of the reaction tank.
- Can be furnished with dry chemical feeders and gravity filters.
- Internals of reaction tank adaptable to concrete tank construction.

JO. 4

WORTHINGTON

WATER CONDITIONING

Worthington Makes More of the Equipment for All Types of Water Conditioning Systems



(*Continued from page 18*)

A jazz collection is our newest project—jazz, however, of a strictly unterpsichorean variety. What we're talking about is the stuff newspapermen employ to sensationalize. And, of course, water works news is all too often subjected to the "jazz it up" technique on the theory that, reported straight, it would remain unread.

First item in our collection comes from Salt Lake City, where headlines on an orange front page screamed "Fire Destroys Water Supply" over a story which began "A forest fire which destroyed Salt Lake City's most important watershed. . . ." Fact of the matter was—the fire, apparently started by three young boys who wanted a thrill, was damaging enough unsensationalized. The City Creek supply, the watershed of which was burned over, provides approximately 13 per cent of the city's water, and though the supply wasn't "destroyed," the destruction of forest cover may well have serious consequences.

Too bad, news has to be very bad to be any good.

Ernest J. Rowe, superintendent of the Wellsville, N.Y., Water & Light Dept., has retired after 31 years of service to his community.

(*Continued on page 82*)

On Call . . .
to tell your story for you!

Willing Water wants work on or as your public relations staff. Let him be your spokesman to your customers . . . to your personnel. You'll find him a master of the art of putting across your ideas...of soliciting co-operation ...of establishing good will. Call him up...put him to work on your publicity, your signs, your bulletins, your bills, your reports...you'll find him ready, able and, of course, willing.

Low-cost blocked electrotypes or newspaper mats, in 32 different poses, are immediately available to you. Write now for a catalog and price list to:

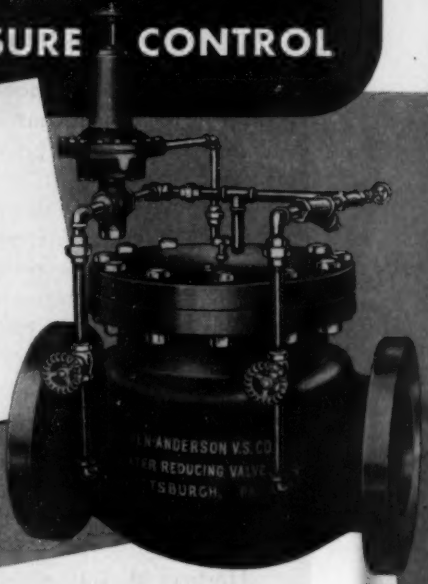
AMERICAN WATER WORKS ASSOCIATION
521 Fifth Avenue . New York 17, New York

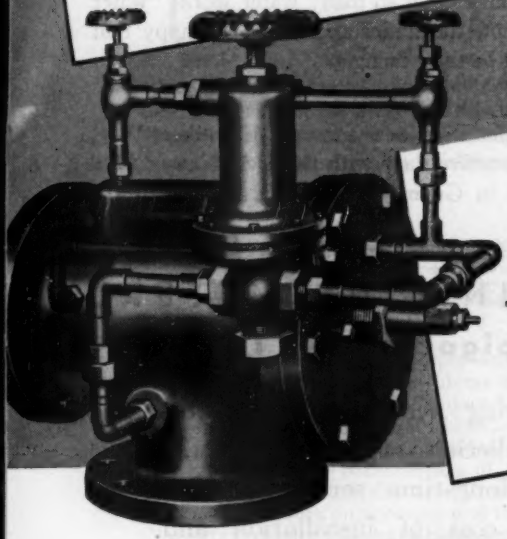
Specifically Designed

for **WATER PRESSURE CONTROL**

GOLDEN-ANDERSON CUSHIONED WATER PRESSURE REDUCING VALVE

Used to protect water lines where high initial pressures would cause serious damage to distribution mains, this very sensitive valve will maintain a uniform delivery pressure. Bulletin W-3 will interest you.





GOLDEN-ANDERSON CUSHIONED SURGE RELIEF VALVE

This valve is used to protect water lines against excessive pressures caused by surges in the system, and will open immediately when inlet pressure exceeds the adjustment of the pilot. Bulletin W-2 sent on request.

For over 50 years, Golden-Anderson has specialized in designing and manufacturing pressure control valves. The patented air and water cushioning feature effectively prevents any bang or hammer.

May our experienced engineers help you with your water pressure control problem?

GOLDEN ANDERSON *Valve Specialty Company*

2091 KEENAN BUILDING • PITTSBURGH 22, PA.

(Continued from page 80)

More than 20,000 housebreakers have just been legalized in Britain as a result of a recent court decision in favor of some gas company officials who forced entry into a private residence to inspect gas fittings and remove money from the meter. Noting the fact that water works men are not among the 20,000 the *British Waterworks Officers' Journal* is quick to point out that rodent officers (rat catchers, that is) are and that an empty house is still private property. Whether or not this was meant to indicate that, empty or not, a house is now bound to be infested by rats of one kind or another is not certain, but for the moment we'll let that go.

What the order certainly does is put water works men in their place, with the bobbies (policemen, that is), requiring that they obtain a magistrate's warrant before insisting upon entry into any Englishman's "castle." Perhaps that's only what comes from calling so many water works "water undertakings," but, aspersion or not, the undertakers can be happy that desanctification of the home will not be their doing.

Home was never like this!

Herbert M. Ihling, formerly field engineer for the Milwaukee, Wis., Water Works, has been recalled to active duty with the U.S. Navy's Civil Engineer Corps. He is stationed in Guam, where he is serving at the Public Works Center.

(Continued on page 84)

SPARLING MAIN-LINE METERS
for Bell & Spigot Lines, Too

Whatever your metering need, a few minutes study of Sparling Bulletin 311 will reveal the main-line meter for long-time service at low cost of installation and maintenance!

Descriptive Bulletin 311 comes on request

SPARLING METER COMPANY
INCORPORATED

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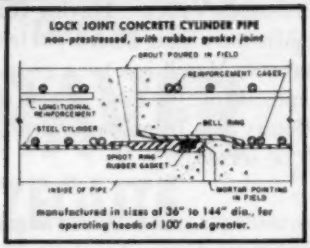
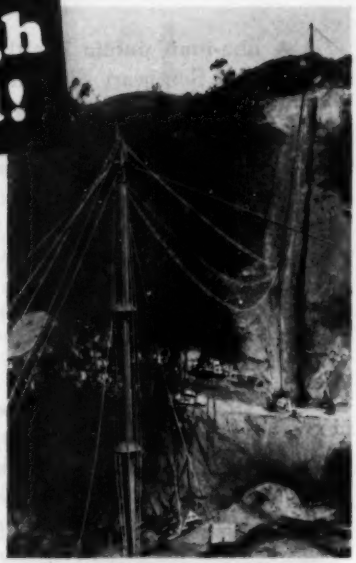
CHICAGO 8.....1500 South Western Ave.
SEATTLE 1.....1932 First Avenue
NEW YORK 17 ..... 101 Park Avenue
626 Broadway ..... CINCINNATI 2
6 Beacon Street ..... BOSTON 8
726 Reserve Loan Life Bldg. ..... DALLAS 1
66 Luckie Street N.W. ..... ATLANTA 3

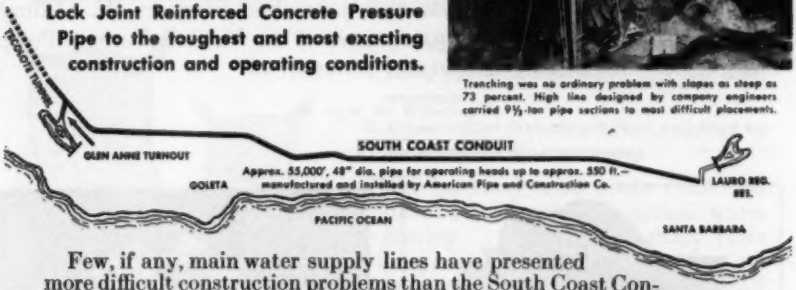
Rough, Tough and Rugged!


LOCK JOINT CONCRETE CYLINDER PIPE
non-prestressed, with rubber gasket joint
GROUT POURED IN FIELD
REINFORCEMENT CAGES
LONGITUDINAL REINFORCEMENT
STEEL CYLINDER
BELL RING
SPIGOT RING
RUBBER GASKET
INSIDE OF PIPE
MORTAR POINTING IN FIELD
manufactured in sizes of 36" to 144" dia., for operating heads of 100' and greater.



Trenching was no ordinary problem with slopes as steep as 73 percent. High line designed by company engineers carried 9½-ton pipe sections to most difficult placements.

Great South Coast Conduit of Bureau of Reclamation again proves adaptability of Lock Joint Reinforced Concrete Pressure Pipe to the toughest and most exacting construction and operating conditions.


TECOLOTE TUNNEL
GLEN ANNE TURNOUT
SOUTH COAST CONDUIT
Approx. 55,000', 48" dia. pipe for operating heads up to approx. 550 ft.—manufactured and installed by American Pipe and Construction Co.
GOLETA
LAURO RES. EST.
PACIFIC OCEAN
SANTA BARBARA

Few, if any, main water supply lines have presented more difficult construction problems than the South Coast Conduit of the Cachuma Water Project. Spanning the mountains and valleys of the precipitous terrain between Tecolote Tunnel and the Santa Barbara area, the line was considered one of the toughest projects of this kind since the construction of the San Diego Aqueduct, which also used Lock Joint Reinforced Concrete Pressure Pipe. Now nearly completed, modern engineering and the superior qualities of Lock Joint Concrete Cylinder Pipe have helped make it practicable. Illustrations indicate some of the ways this versatile pipe met the needs of this rough, tough, rugged job.

This line is a brilliant example of permanent reinforced concrete pipe line construction. It will serve the Santa Barbara area for generations at peak performance and minimum maintenance expense. The same advantages are available to you for your project—advantages that mean reductions in the cost of delivered water.

American PIPE AND CONSTRUCTION CO.

Concrete Pipe for Main Water Supply Lines, Storm and Sanitary Sewers, Subaqueous Pipe Lines

P. O. Box 3428, Terminal Annex, Los Angeles 54, California

Main Offices and Plant—4635 Firestone Blvd., South Gate, Calif.

District Sales Offices and Plants — Oakland • San Diego • Portland, Ore.

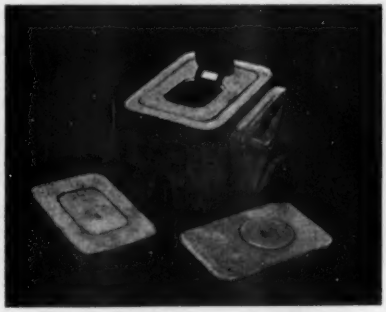
(*Continued from page 82*)

A one-man public health service is Arthur C. Magill, chemistry professor at Southeast Missouri State College, who, following a personal tragedy involving typhoid, began in 1908 to test water samples for the "typhoid germ" for anyone for free. Making typhoid information his spare-time interest, Dr. Magill has tested more than 35,000 suspected water samples from places all through the Mississippi Valley. Having received a special award of merit presented by the Missouri State Board of Health and the Missouri Water and Sewage Conference, Magill has been given special recognition, too, in an article in the September 1951 issue of the *Rotarian* for distinguished service not only to Rotary and to public health but to a host of other civic organizations which he serves.

V. Gerbereux, formerly assistant manager of the Centrifugal Pump Sales Div., Worthington Pump & Machinery Corp., has been appointed manager of the division, succeeding A. H. Borchardt, recently elected a vice president of the corporation. Another promotion advances W. Clifford Mumford from acting manager to manager of the Vertical Turbine Pump Sales Div., with Fenmore E. Dunn as his assistant.

(*Continued on page 86*)

CARSON CLAMPS
AND PEARLITIC CAST IRON BOLTS
Stop Joint Leakage
Write for Information
H. Y. CARSON
1221 Pinson St. Birmingham, Ala.



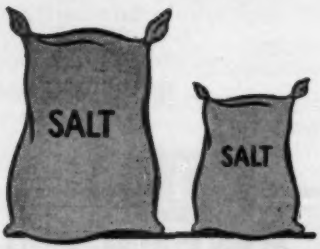
FAITHFUL AND DEPENDABLE SERVICE SINCE 1911!

For over four decades Art Concrete Meter and Valve Boxes have been used by many cities along the Pacific Coast and throughout the entire South. You, too, can benefit from this broad experience gained in solving numerous water works problems! Write for free catalog.

ART CONCRETE WORKS
PASADENA, CALIF.
OAKLAND, CALIF. PORTLAND, ORE.
JACKSONVILLE, FLA. HIALEAH, FLA.
BIRMINGHAM, ALA. CHARLOTTE, N. C.
SOUTH HOUSTON, TEX. SHREVEPORT, LA.

Savings you make

WITH GRAVER ZEOLITE SOFTENERS



OLDER TYPES OF ZEOLITE SOFTENERS AND ZEOLITES require 0.45 to 0.60 lb. of salt per kilograin of hardness removed.

GRAVER MODERN ZEOLITE SOFTENERS WITH GRAVER RESIN ZEOLITES require 0.20 to 0.35 lb. of salt per kilograin of hardness removed.

Write for copies of "Present Practices in the Use of Ion Exchange in Water Treatment".

Economical salt regenerating dosages are essential in the softening of municipal water supplies where tremendous quantities of water are to be softened. Low initial costs and easily operated equipment are also factors to be considered where limited budgets are a municipal problem.

GRAVER highly efficient zeolite softeners with resin zeolites are designed to give:

1. Savings in salt for lower operating costs
2. Easily operated equipment with low labor expense
3. Lower initial investment than required by conventional lime softening

There are many reasons why GRAVER assures best results in zeolite water softening . . . more than thirty years of experience in the design of ion exchange equipment . . . a skilled staff of chemical engineers who have pioneered the commercial application of many ion exchange processes . . . an efficient laboratory and pilot plant to develop new methods to improve regeneration and operating techniques . . . outstanding records made by large and smaller installations in the water treatment and liquid conditioning field.

Let GRAVER specialists help you in the solution of your water treatment problem. Send us an analysis or a sample of your water supply. Your request for information will not involve any obligation on your part. GW-422

GRAVER WATER CONDITIONING CO.
216 WEST 14 STREET, NEW YORK 11, N. Y.

GRAVER
DIVISION OF
GRAVER TANK & MFG. CO. INC.

(*Continued from page 84*)

Water, water everywhere all the time, at the same time, for the first time in two years is the story of Amsterdam, Ohio. Now that a big leak in its distribution system has at last been discovered and repaired, the city no longer needs to ration its water to give only half its citizens service in the morning, the other half in the afternoon. As a matter of fact, to assure future drops to drink, an aroused Amsterdam now plans to build a reservoir and filter plant supplementing its present two wells.

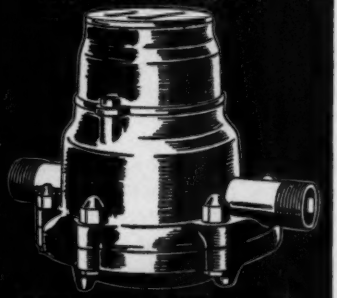
To have is to hold and even to have a little more.

C. S. White has been appointed manager of the Eastern Div. of Dearborn Chemical Co., with headquarters in New York.

What is known as "productive maintenance" has been set up by General Electric Co. as a plan for helping industry get the most production from its equipment. The plan recommends an adequate staff of trained maintenance men; proper tools; regular routine checks of equipment, including planned removals of equipment from service for rebuilding and modernizing; and an adequate stock of spare parts.

(*Continued on page 88*)

SIMPLICITY of American Meters PAYS OFF for You!



Buffalo AMERICAN Meters are simply designed, with fewer working parts — save money for you through lower maintenance and replacement costs. Write for details.

BUFFALO METER COMPANY

2914 Main Street
Buffalo 14, New York

OMEGA

THE LAST WORD IN FEEDERS . . .

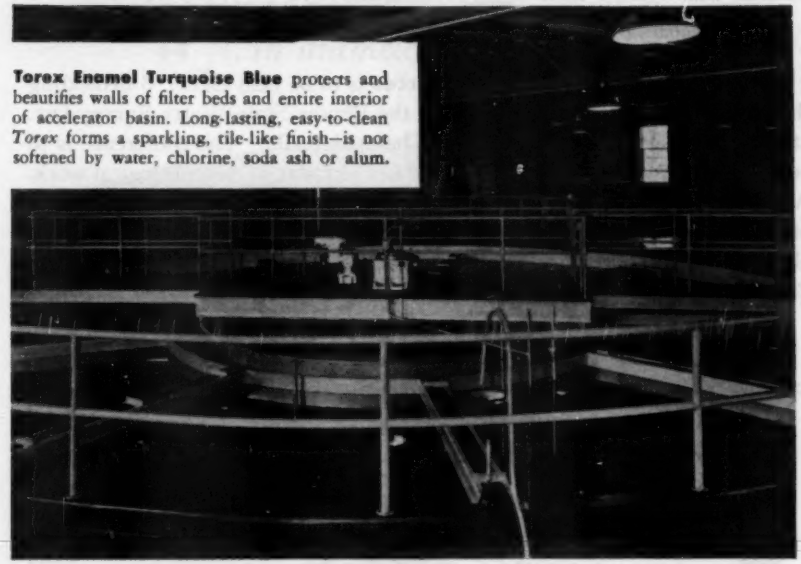
— for alum, lime, soda ash, ferric sulphate, sodium fluoride, carbon, and other water treatment chemicals. For Bulletins and complete information, address Omega Machine Company, (Division of Builders Iron Foundry) 365 Harris Ave., Providence 1, R. I.

OMEGA MACHINE CO.

INERTOL PAINTS

specified at sparkling Wisconsin Filter Plant

Superior Inertol coatings exceed requirements



Torex Enamel Turquoise Blue protects and beautifies walls of filter beds and entire interior of accelerator basin. Long-lasting, easy-to-clean *Torex* forms a sparkling, tile-like finish—is not softened by water, chlorine, soda ash or alum.

● Here at the spotless City of Wisconsin Rapids (Wisconsin) Filter Plant, Inertol Paints were specified because of the assurances of long-range quality performance. City engineers V. W. Baker, Superintendent of the Water Plant, and L. L. Klinger, Central Control Laboratory Chemist of the Consolidated Water Power and Paper Company, knew from experience that these superior coatings would far exceed the requirements of hardness, elasticity, chemical inertness and beauty. Each product in the Inertol line has been developed specifically for water works application. The reliability of these Inertol Paints has been *proved* in hundreds of installations throughout the country.

If you are interested in the most suitable type of surface coatings that can be specified with complete satisfaction, our Field Technicians will be pleased to discuss this line fully with you at your office. Or write today for the "Painting Guide," an invaluable aid for Design Engineers, Specification Writers, Contractors and Plant Superintendents.

INERTOL CO., INC.

480 Frelinghuysen Avenue
Newark 5, New Jersey

27 South Park, Department 1
San Francisco 7, California

(*Continued from page 86*)

A 50,000,000,000-gallon man is Louis B. Harrison, superintendent of the Bay City, Mich., filtration plant. And having supervised the treatment of that much water, and having a perfect record of keeping it available, Louis rates the title of "Health Protector," conferred upon him by the Bay City *Times* in a recent three-column biographical sketch. Happy as we are to see Louis get some well-deserved recognition for his 35 years of meritorious service to the city, we're no less happy at the whole idea of the *Times* in giving its readers an introduction to the various municipal officials who operate their city government.

Not *apres,* but *avec* this Louis, *le deluge!*

A Conference on Water Resources is to be held Oct. 1–3 dedicating the new Water Resources Building of the Illinois State Water Survey Div. at the University of Illinois, Urbana-Champaign, Ill. The conference is to be devoted to hydrology, treatment and use of radar in meteorological work. A number of discussions are planned for each session, and it is planned to publish the proceedings of the conference. Further information may be obtained from the Dedication Conference Chairman, State Water Survey, Box 232, Urbana, Ill.

(*Continued on page 90*)

Now Available:

WATER QUALITY & TREATMENT

Second Edition—Revised and Enlarged

A.W.W.A.'s manual of *Water Quality and Treatment* brought up to date, with chapters on: source characteristics; aquatic organisms, quality standards, stream pollution and self-purification, impounding reservoir control, aeration, coagulation, mixing and sedimentation basins, disinfection, taste and odor control, filtration, scale and corrosion control, softening, iron and manganese removal, boiler water treatment, fluoridation, and treatment plant control. With four appendixes and an index, that makes 451 pages.

Price: For general sales, $5.00. For A.W.W.A. members sending cash with order, $4.25

AMERICAN WATER WORKS ASSOCIATION

521 Fifth Avenue New York 17, N.Y.

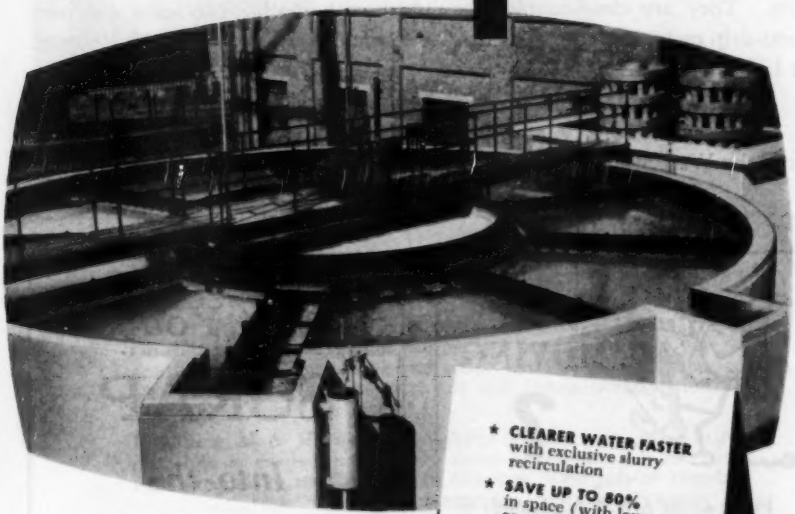
AT OCALA, FLORIDA

compact **Infilco** *plant softens 4 M.G.D. with ACCELATOR only 44 ft. in diameter*

clear, non-corrosive soft water with

Accelator®

In treating well water of 20 grain per gallon hardness this Infilco installation uses the slurry recirculation principle of the Accelator to soften and clarify a comparatively large volume in very small space. Settling basins are eliminated. Effluent is clear, aerated for non-corrosiveness, and reduced in hardness to 5 gr. per gallon.



* **CLEARER WATER FASTER** with exclusive slurry recirculation
* **SAVE UP TO 80%** in space (with lower construction costs)
* **SIMPLER OPERATION** — mixing, coagulation, clarification and sludge removal all in one unit.
* **FASTER CHEMICAL REACTION**
* **HIGH RATINGS**

Plant Engineered by

RUSSELL & AXON *Daytona Beach, Florida*

44 ft. diameter Accelator — with automatic chemical feeders and central controls. 2 Multicone Aerators 3 Filters, each 16 x 22 ft. with Wagner underdrains. Serves population of 11,588 with average daily use of 1.5 m.g.d. and capacity of 4.0 m.g.d.

INFILCO — BETTER WATER CONDITIONING AND WASTE TREATMENT SINCE 1914

INFILCO INCORPORATED | *Tucson, Arizona*

FIELD ENGINEERING OFFICES IN 26 PRINCIPAL CITIES

World's Leading Manufacturers of Water Conditioning and Waste-Treating Equipment

(*Continued from page 88*)

William J. Fleming has been appointed manager of the Construction Equipment Sales Div. of Worthington Pump & Machinery Corp.

Diamond Alkali Co. has acquired the common stock of Kolker Chemical Works, Inc., of Newark, N.J., manufacturer of organic insecticides and agricultural chemicals. The acquisition adds such products as DDT, benzene hexachloride, 2,4–D weed killer and 2,4,5–T brush killer to the Diamond line.

A new line of general purpose centrifugal pumps, the Type SCC, has been designed by Economy Pumps, Inc., Div. of Hamilton-Thomas Corp. The pumps are light in weight and are intended for any small pump application. They are close-coupled, equipped with mechanical seals and have open-drip motors. The types now available offer capacities up to 100 gpm. at 120 ft. of head.

The New York Water Service Co. is planning to move its offices from the Wall St. district to 132 W. 43rd St., New York City.

Are you
MOVING
?

Please advise A.W.W.A. promptly of any change in your mailing address. Leaving a forwarding address at your old post office is not enough, because postal regulations require periodicals to be returned to the sender if not claimed at the original destination. And, to help us identify you properly, please include your old as well as your new address when writing.

Prompt notification will keep your Journals and other communications coming to you without annoying delays and lapses.

American Water Works Assn., Inc.
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Get Your
SCRAP
Into the
SCRAP

★

Sell stuff and junk and things to your local scrap dealer.

What does a VALVE COST?

M & H Mechanical Joint
IBBM AWWA Gate Valve

Purchase price (or first cost) of a valve is not its real cost. Maintenance engineers appraise the true cost of a valve as cost per year of service—i.e., purchase price plus maintenance costs divided by years in operation.

On that basis, M & H likes comparison because M & H Valves are designed to last longer and entail little or no maintenance cost. Sizes 2 to 30-inch, with all end connections, including Mechanical Joint as shown.

Installing M & H Mechanical-Joint Valves into an existing pipe line is easily and quickly done by common labor with Mechanical Joint Cutting-In Sleeves. The job of regular inspection and maintenance of fire hydrants is also greatly simplified if auxiliary valves are installed for each hydrant, and an M & H Mechanical-Joint Valve makes such a job an easy one.

MECHANICAL JOINT
CUTTING-IN SLEEVE

M & H VALVE
AND FITTINGS COMPANY
ANNISTON, ALABAMA

M&H PRODUCTS *Everywhere*

SOLVAY
Trade-Mark Reg. U. S. Pat. Off.
PRODUCTS
For Water Treatment

For Water Softening...

...SOLVAY SODA ASH

For Water Purification...

...SOLVAY LIQUID CHLORINE

For Water Technical Service...

...Call SOLVAY

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Bulletin No. 8—"Alkalies and Chlorine in the Treatment of Municipal and Industrial Water"
Bulletin No. 11—"Water Analysis"

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Service Lines

A manual for the "Installation, Operation and Maintenance of Chain Drives and Conveyors" is being offered by Chain Belt Co., 1600 W. Bruce St., Dept. PR, Milwaukee 4, Wis. Known as Bul. 51-7, the 32-page handbook offers simple, illustrated directions for the use and upkeep of chains and drive equipment.

"Chronoflo Sequence Transmission" is the title of a folder (Supp. Bul. 230-H10) which describes and illustrates equipment designed to transmit multiple functions over a single pair of wires without using carrier frequencies. Information required by the telephone company when wires are leased is included. The folder is available on request from Builders-Providence, Inc., 345 Harris Ave., Providence 1, R.I.

Dam repairs by the application of gunite to eroded surfaces is the subject of a folder available from the Pressure Concrete Co., 193 Emmet St., Newark 5, N.J.

"Hydrogen Peroxide," a reprint of an article by E. S. Shanley which appeared in the May *Journal of Chemical Education,* is being offered, as Bul. 2A, by the Becco Sales Corp., Sta. B, Buffalo 7, N.Y. The article discusses the nature and uses of the chemical.

A new line of laboratory microscopes featuring effortless focusing is shown in a catalog of Dynoptic Labroscopes issued by Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N.Y.

(*Continued on page 94*)

...AND IN PUMPING STATIONS AROUND THE NATION

IT'S "PEERLESS PUMPS *PREFERRED*"

Your complete city pumping cycle from water supply through sewage and wastes disposal can be efficiently and economically handled by one make of pump – Peerless. So why not follow the lead of thousands of communities across the nation from New York to California and place your water supply, boosting and disposal problems, with undivided responsibility for the whole job, in the capable hands of Peerless pump engineers. Whether it's for pumps to supply 100,000,000 m.g.d., such as for the city of New York, or for pumps to dispose of sewage at 6,000 g.p.m., such as for the city of Manhattan Beach, Calif. Peerless knows you can cut your time, investment and maintenance by standardizing on Peerless as your one source of pumps. Request individual bulletins on the type of Peerless pump you require for your pumping problem.

PEERLESS PUMP DIVISION
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Address inquiries to factories at:
LOS ANGELES 31, CALIFORNIA AND INDIANAPOLIS 8, INDIANA
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GREENBERG

Independently Valved HYDRANTS

for non-freezing climates

Western water works engineers and fire chiefs were the first to approve Greenberg California-type fire hydrants. Now, after exhaustive tests, Underwriters' Laboratories, Inc. has confirmed your judgment.

Greenberg No. 74 and 76 hydrants are equipped with independent valves of a new type which open quickly and easily, allowing full flow with minimum resistance. They close tightly without water hammer. A major improvement over the old "cork in bottle" type valve!

Other innovations such as you would expect of the people who evolved the California-type hydrant 75 years ago are shown in the free booklet "Hydrants by Greenberg." May we send you a copy?

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Los Angeles • Seattle • Portland • Spokane • Salt Lake City • Denver • El Paso • New York • Hartford
Washington, D. C.

(*Continued from page 92*)

A new belt gravimetric feeder is the subject of Bul. 35-H5 on the Chemizer of Omega Machine Co., 345 Harris Ave., Providence 1, R.I.

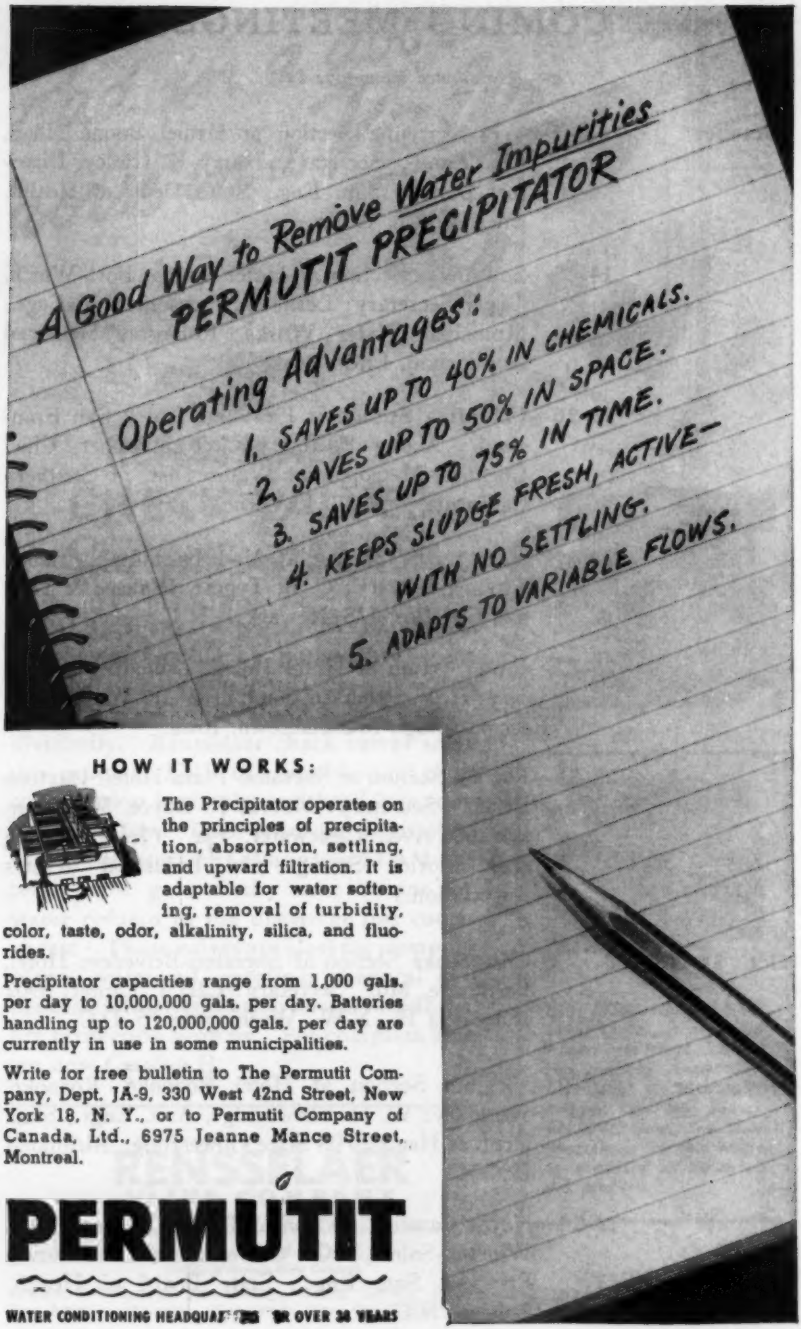
Packaged electric power units for industrial expansion are described and installation procedures for them illustrated in a new 24-page bulletin—GEA-5600. A checklist of other bulletins on equipment available from the company is included.

"Allotment Accounting for Consumers Under CMP" is the title of a bulletin distributed by the National Production Authority, Dept. of Commerce, Washington 25, D.C., in explanation of the records that must be kept for the Controlled Materials Plan. The bulletin has an effective date of May 15, and is subject to later revisions in procedure.

A bulletin explaining the working of the heavy duty type wedge-lock coupling for use on temporary or permanent pipeline installations. Designed for use with Naylor Pipe Co. lightweight pipe, the coupling is connected with the aid of a hammer. The folder may be obtained from the company at 1230 E. 92 St., Chicago 19, Ill.

Cathodic protection by the "Westalite" constant current system is the subject of a folder available from Westinghouse Brake & Signal Co., Ltd., 82 York Way, King's Cross, London, N.I. The system is designed to compensate automatically for changes in soil resistance, thus maintaining a constant level of protective current flow.

Single-tank deionizers of mixed-bed, monoflo design which give up to 44 per cent more capacity than previous designs are described in Bul. 512 of Elgin Softener Corp., 134 N. Grove Ave., Elgin, Ill. The unit is known as the Elgin Ultra Deionizer.


A Good Way to Remove Water Impurities
PERMUTIT PRECIPITATOR
Operating Advantages:
1. SAVES UP TO 40% IN CHEMICALS.
2. SAVES UP TO 50% IN SPACE.
3. SAVES UP TO 75% IN TIME.
4. KEEPS SLUDGE FRESH, ACTIVE—
WITH NO SETTLING.
5. ADAPTS TO VARIABLE FLOWS.

HOW IT WORKS:

The Precipitator operates on the principles of precipitation, absorption, settling, and upward filtration. It is adaptable for water softening, removal of turbidity, color, taste, odor, alkalinity, silica, and fluorides.

Precipitator capacities range from 1,000 gals. per day to 10,000,000 gals. per day. Batteries handling up to 120,000,000 gals. per day are currently in use in some municipalities.

Write for free bulletin to The Permutit Company, Dept. JA-9, 330 West 42nd Street, New York 18, N. Y., or to Permutit Company of Canada, Ltd., 6975 Jeanne Mance Street, Montreal.

PERMUTIT

WATER CONDITIONING HEADQUARTERS FOR OVER 38 YEARS

COMING MEETINGS

(*Continued from page viii*)

October

4–5—West Virginia Section at Daniel Boone Hotel, Charleston. Secretary: Harry K. Gidley, Director, Div. of San. Eng., State Dept. of Health, Charleston 5, W.Va.

14–17—Southwest Section at Hotel Texas, Fort Worth, Tex. Secretary: Leslie A. Jackson, Mgr.-Engr., Municipal Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

23–26—California Section at Fairmont Hotel, San Francisco. Acting Secretary: Lee Streicher, Chief Chemist, Metropolitan Water Dist. of Southern California, Box 38, LaVerne, Calif.

25–27—New Jersey Section at Madison Hotel, Atlantic City. Secretary: C. B. Tygert, Wallace & Tiernan Co., Box 178, Newark 1, N.J.

25–27—Iowa Section at Hotel Julian, Dubuque. Secretary: H. V. Pedersen, Supt. of Water Works, Municipal Bldg., Marshalltown, Iowa.

28–31—Florida Section at Sheraton Plaza Hotel, Daytona Beach. Secretary: Marvin R. Boyce, 504 Pennsylvania Ave., Clearwater, Fla. (Joint meeting with Florida Sewage and Industrial Wastes Association.)

Oct. 31–Nov. 2—Chesapeake Section at Sheraton-Belvedere Hotel, Baltimore, Md. Secretary: Carl J. Lauter, 5902 Dalecarlia Pl., N.W., Washington 16, D.C.

November

7–9—Virginia Section at Hotel Roanoke, Roanoke. Secretary: W. H. Shewbridge, Asst. Engr., State Dept. of Health, 708 State Office Bldg., Richmond 19, Va.

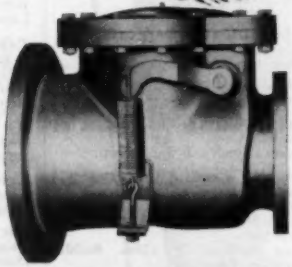
12–14—North Carolina Section at Robert E. Lee Hotel, Winston-Salem, N.C. Secretary: E. C. Hubbard, Principal San. Engr., State Board of Health, Raleigh, N.C.

Bad in a door—worse in a Valve

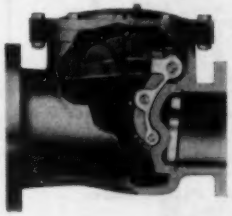
RENSSELAER

CHECK VALVES

Seat without **SLAM**



THERE'S always possibility of serious SLAM trouble on pump shut down especially where gradient is steep or where pumps are manifolded and shut down individually. Rensselaer check valves solve this problem, END this trouble—yet their construction is simple, and head loss comparatively low. Their lever-and-adjustable-spring-construction eliminates SLAM by seating the gate at the same instant the water column in the discharge line comes to rest. These valves are ideal for pumping plants; water, oil, gasoline; chemical and process industries; marine service, drydocks; fire protection systems. For complete data see new Catalog H.



Heavy Stainless Steel Main Hinge Shaft...Heavy Solid Bronze Gate Hinge...Stainless Steel Key...Dual Stainless Steel Gate Pins... Rugged Cast Iron Bronze Mounted Gate. See your Rensselaer Representative for seasoned advice on all our products.

10

LEADERSHIP FOR OVER 65 YEARS

RENSSELAER

VALVE COMPANY

Hydrants • Gate Valves • Square Bottom Valves
Check Valves • Tapping Sleeves and Valves • Air Release Valves

TROY, NEW YORK

Division of Hoffman Meter Company

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(See Prof. Services, pp. 25–29)

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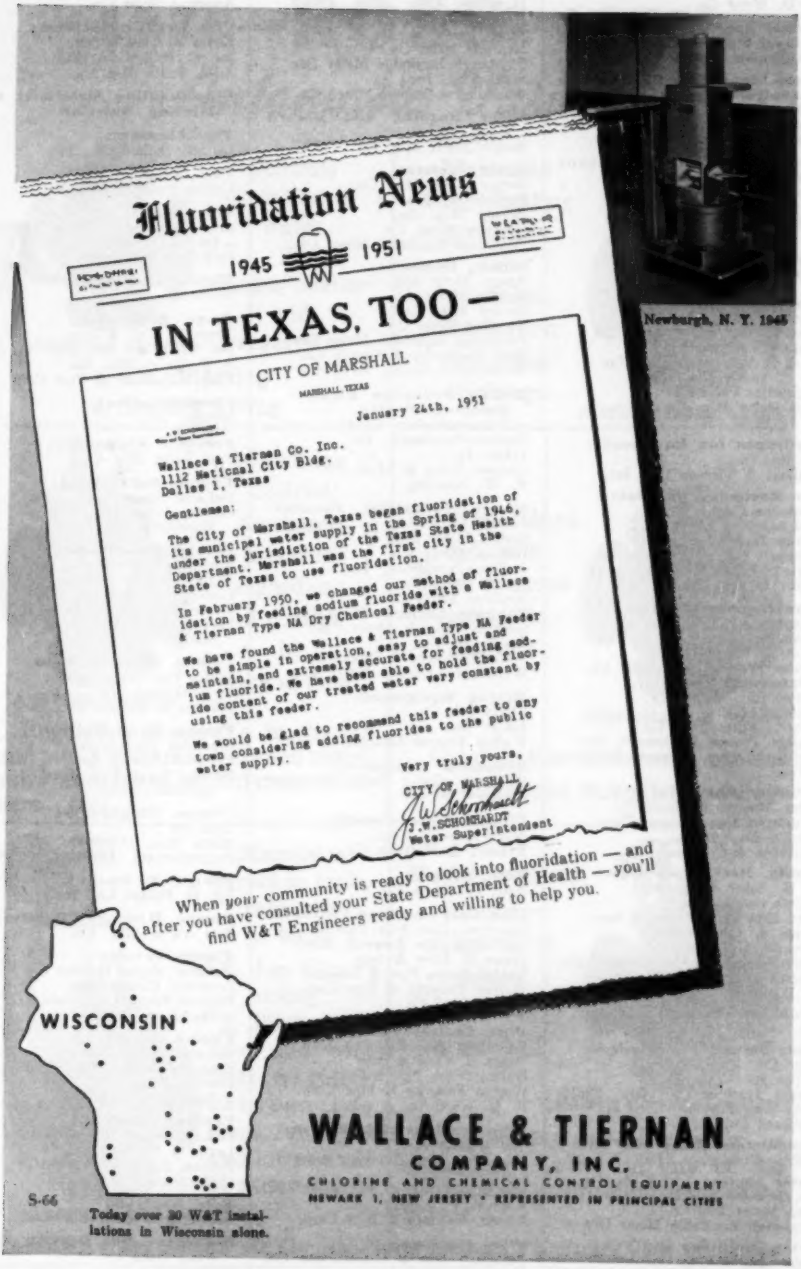
Fluoridation News
1945 1951
IN TEXAS, TOO—
CITY OF MARSHALL
MARSHALL, TEXAS
January 24th, 1951
Wallace & Tiernan Co. Inc.
1112 National City Bldg.
Dallas 1, Texas
Gentlemen:
The City of Marshall, Texas began fluoridation of its municipal water supply in the Spring of 1946, under the jurisdiction of the Texas State Health Department. Marshall was the first city in the State of Texas to use fluoridation.
In February 1950, we changed our method of fluoridation by feeding sodium fluoride with a Wallace & Tiernan Type NA Dry Chemical Feeder.
We have found the Wallace & Tiernan Type NA Feeder to be simple in operation, easy to adjust and maintain, and extremely accurate for feeding sodium fluoride. We have been able to hold the fluoride content of our treated water very constant by using this feeder.
We would be glad to recommend this feeder to any town considering adding fluorides to the public water supply.
Very truly yours,
CITY OF MARSHALL
J.W.SCHOMBARDT
Water Superintendent
Newburgh, N. Y. 1945
When your community is ready to look into fluoridation — and after you have consulted your State Department of Health — you'll find W&T Engineers ready and willing to help you.
WISCONSIN
S-66
Today over 30 W&T installations in Wisconsin alone.
WALLACE & TIERNAN
COMPANY, INC.
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES

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1879—ROSS—1879

Automatic Valves

ALTITUDE VALVE

Controls elevation of water in tanks, basins and reservoirs

1. Single Acting
2. Double Acting

Maintains safe operating pressures for conduits, distribution and pump discharge

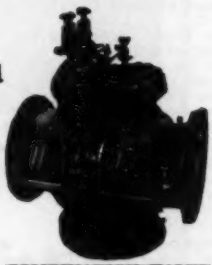
SURGE-RELIEF VALVE

REDUCING VALVE

Maintains desired discharge pressure regardless of change in rate of flow

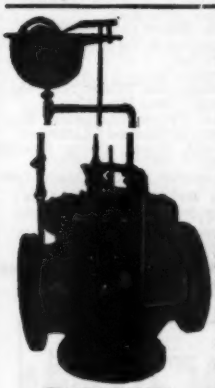
Regulates pressure in gravity and pump systems; between reservoirs and zones of different pressures, etc.

A self contained unit with three or more automatic controls



COMBINATION VALVE

Combination automatic control both directions through the valve.



FLOAT VALVE

Maintains levels in tank, reservoir or basin

1. As direct acting
2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

Electric remote control—solenoid or motor can be furnished

REMOTE CONTROL VALVE

Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

Packing Replacements for all Ross Valves Through Top of Valve

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Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Dearborn Chemical Co.
Inertol Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dearborn Chemical Co.
Dorr Co.
Everson Mfg. Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.
Worthington Pump & Mach. Corp.

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

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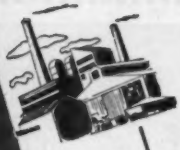

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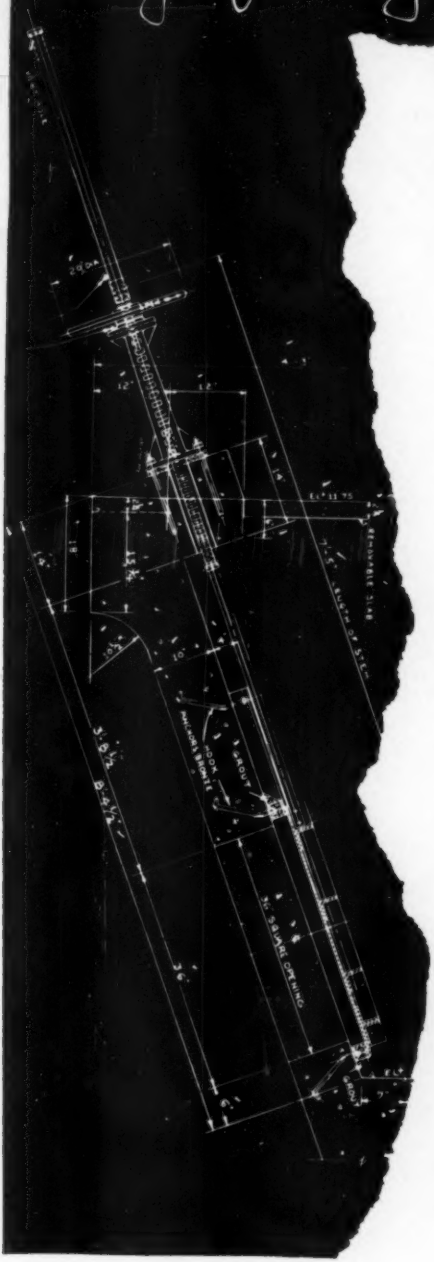

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